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"WORD-BLINDNESS" IN SCHOOL CHILDREN

and

OTHER PAPERS ON STREPHOSYMBOLIA

(*Specific Language Disability—Dyslexia*)

1925 - 1946

by

SAMUEL TORREY ORTON, M.D.

Compiled by

JUNE LYDAY ORTON

Published by

THE ORTON SOCIETY, INC.

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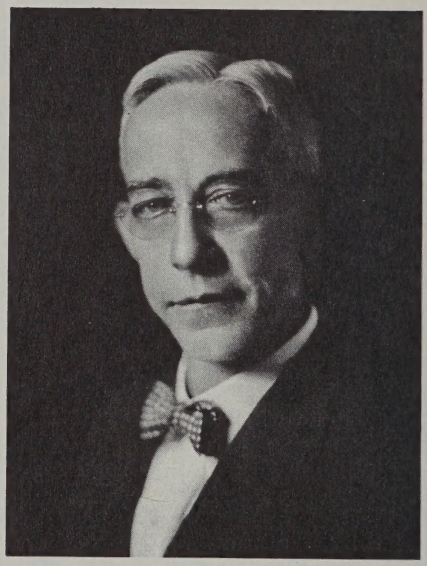

SAMUEL TORREY ORTON, M.D.

1879 - 1948

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Foreword

THE ORTON SOCIETY, INC., is performing a valuable service both to research students and to those actively engaged in work with dyslexic children by publishing this compilation of papers by the late Dr. Samuel T. Orton. As one who has recently had occasion to review over 500 references in the field, this writer can attest to the difficulties involved in searching the medical libraries for such articles and also the reward in finding any of Orton's lectures on developmental language disabilities. The originality of his thinking, the clarity of his expression, and the urgency of his appeal for better understanding of these neglected children come through so clearly in his writings that we can assure the reader that he will find his own ideas stimulated as he follows the development of Orton's work over a period of twenty years. To those of us who had the opportunity of knowing Sam Orton personally, these printed words of his bring a happy glow of memory of the strong and kindly personality which shone through all of his professional undertakings.

LLOYD J. THOMPSON, M.D.
Chapel Hill, North Carolina

September, 1966.

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Dr. Lloyd J. Thompson is Clinical Professor Emeritus of Psychiatry at the University of North Carolina and author of *Reading Disability: Developmental Dyslexia.* Charles C. Thomas, publisher, Springfield, Illinois, 1966.

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REPRINTS OF PAPERS BY SAMUEL TORREY ORTON, M.D.
DEVELOPMENTAL LANGUAGE DISABILITIES

1. "Word-Blindness" in School Children
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2. FOREWORD to "Methods for Diagnosis and Treatment of Cases of Reading Disability" by Marion Monroe. From the Iowa Psychopathic Hospital
Genetic Psychology Monographs,
Vol. IV, Nos. 4 and 5, Oct.-Nov., 1928 53

3. Specific Reading Disability — Strephosymbolia
Journal of the American Medical Association,
Vol. 90, 1095-1099, April 7, 1928 59

4. Neurological Studies of Some Educational Deviates from Iowa Schools
Journal of the Iowa State Medical Society, April, 1929 71

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School and Society, Vol. XXVIII, No. 715, Sept. 8, 1928 99

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Journal of Educational Psychology, pp. 135-142, Feb., 1929 105

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Proceedings, Association for Research in Nervous and Mental Disease, Vol. XIII, 1932 147

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Child Research Clinic Series, Woods Schools,
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The Educational Record, Supplement No. 12, 58-68, Jan., 1939 .. 243

18. Visual Functions in Strephosymbolia
Archives of Ophthalmology, Vol. 30, 707-713, Dec., 1943 255

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Preface

THE ORTON SOCIETY, INC., takes pleasure in presenting this collection of reprints of papers by SAMUEL TORREY ORTON, M.D., in whose honor the Society was named and whose pioneer work with dyslexic children continues to be an inspiration and a guide to many others in the field.

These papers are arranged for the most part in the chronological order in which they appeared in the professional journals and are representative of the many talks which Dr. Orton gave on these subjects between 1925 and 1946. They are not intended to be read consecutively as chapters in a book but separately as individual articles in a bibliography of references on developmental language disabilities. Each one is quite complete in itself, explaining the same general thesis and using many of the same illustrations as in the others. These repetitions, however, do not obscure the steady development of Dr. Orton's concepts over the years as he continued to observe and work with children with many forms of specific language problems. The careful reader will be interested in discovering these subtle changes and broadening theories while enjoying the many felicitous variations in the author's phrasing of his basic themes. The two articles on the correlated subjects of spelling and writing are still so much in demand that they will be made available as separate reprints.

This compilation of Dr. Orton's papers is introduced by a chapter about the man himself and includes a biographical sketch of his professional background, some impressions of his personality by one of his former medical students, and his own account of his philosophy of organic psychiatry. In the Appendix can be found a bibliography of all of the published articles by Dr. Orton which have been located to date. If any of our readers come across others, the Society would appreciate information about them.

Acknowledgments

THE ORTON SOCIETY, INC. is grateful to John M. Dorsey, M.D., Wayne State University Professor, for the quotations from his manuscript, "Samuel Torrey Orton — A Medical Tribute", and to the following publishers for permissions to reprint the articles which are individually credited to their publications:

American Association for the Study of the Feebleminded
Association for Research in Nervous and Mental Disease
Bulletin of the Neurological Institute of New York
Eugenics Quarterly
Journal of Educational Psychology
Journal of the Iowa State Medical Society
McGregor Fund and Chas. C. Thomas, Publisher
New England Journal of Medicine
Specialty Journals of the American Medical Association
    Archives of Neurology and Psychiatry
    Archives of Ophthalmology
Woods Schools, Child Research Publications

Our primary indebtedness and enduring gratitude belong, of course, to the author of these papers, Samuel Torrey Orton, M.D.

Introduction

BIOGRAPHICAL SKETCH

IT was in Iowa in 1925 that Dr. Samuel T. Orton began his studies of children with specific language disabilities and called the attention of his colleagues in neurology and psychiatry to the large numbers of pupils otherwise normal in every respect who were retarded in their educational and personality development by a special difficulty in learning to read. Dr. Orton subsequently originated a combined medical-psychiatric-educational approach to the diagnosis and treatment of children with developmental language disorders which challenged the prevailing currents of thought in each of these disciplines.

Sporadic cases of "congenital word blindness" had been previously reported in the medical annals, chiefly from abroad, describing individuals who had never been able to learn to read and likening them to certain aphasic adults whose language function had been more or less permanently impaired by brain damage.

In psychiatric circles attention was being given to children through the organization of child guidance clinics with the new "team" concept of psychiatrist, psychologist, and psychiatric social worker, all of whom were generally committed to the principles of emotional causation for the many problems of childhood, including poor school performance.

Educational surveys were already bringing to light a surprising number of very poor readers among high school students and an even larger percentage among delinquents, while the educators were vigorously defending the fairly new "whole-word" or "sight" method of teaching reading and the ultra-progressive schools were expecting their pupils to acquire reading incidentally through other activities of their own choice.

In marked contrast to all this came Dr. Orton's new and successful approach to a certain type of reading difficulty as a specific learning disability with a genetic, physiological background, one which he demonstrated would respond to a broad but precise program of educational remediation based upon an individual diagnostic study of each case. How this all happened can be surmised perhaps from the following biographical sketches and then compared with his own statement of the development of his psychiatric philosophy which follows them.

SAMUEL TORREY ORTON was born in Columbus, Ohio, on October 15, 1879, of New England ancestry. His father, Edward Orton, LL.D., was a fifth generation descendant of Thomas Orton who migrated to America from England in 1641 and settled in Windsor, Connecticut. He was a noted scientist and educator who became president of Antioch College in Ohio and the first president of Ohio State University, later serving as Ohio State Geologist for twenty years. Samuel T. Orton's mother, Anna Davenport Torrey, was born in Millbury, Massachusetts, not far from the 1640 settlement of her English forebears, the William Torreys. She was a younger sister of Mrs. Alphonso Taft, who became the mother of William Howard Taft, President and Chief Justice of the United States, and of Horace Dutton Taft, founder and headmaster of Taft School at Watertown, Connecticut, where young Sam Orton completed his high school courses.

"Samuel T. is fitting for college and expects to study either medicine or mechanical engineering", wrote Edward Orton in 1896 concerning his son's future. Although the young man chose medicine and made it his life career, his mechanical bent perhaps accounted for his persistent search to discover how things worked, most of all, the human brain. His recreation was in designing and building — boats, tennis courts, gardens, garages, laboratories, hospitals — and in inventing better methods and techniques, from ways of pouring slabs of cement to staining and cutting brain sections for the microscope. He always loved to explore nature, observing, naming and classifying rocks and plants and butterflies from the time he was a small boy tagging along after his father on geological expeditions. While in college he spent two summers with the Ohio State Archeological Society digging in Indian mounds, and his study of the pathological changes in the bones of these early inhabitants formed the basis of his first scientific paper, written while still in medical school. He enjoyed hunting and fishing, played a good game of tennis and even football in his earlier years, and always seemed active and energetic, physically and mentally, in spite of a rather frail physique and many illnesses. His insatiable interest in things about him carried over to people. He added to his store of information wherever he went through easy conversations with a plumber or a president, a small boy or a senior scientist. He admired all forms of good workmanship but he was intolerant of careless techniques or any display of pretentiousness, and he would never compromise on a matter of principle.

After graduating from Taft School, Samuel T. attended Ohio State University for four years and then entered the University of Pennsylvania from which he received his medical degree in 1905, and an honorary doctorate in science forty years later. He also earned a master's degree from Harvard University. He was a member of Alpha Omega Alpha, an honorary medical fraternity, and the honorary scientific society, Sigma Xi.

Always interested in pathology and stimulated by such professors as Dr. Simon Flexner at Pennsylvania, Dr. Orton had the opportunity for further training in that field under the eminent Dr. Frank B. Mallory at the Boston City Hospital, of whom he once wrote, "Meticulous technical methods and the most careful morphological observations were the religion which Mallory instilled into all of his students." There he also came under the influence of Dr. E. E. Southard who was specializing in the pathology of the nervous system and later gave him the opportunity for an extended research study of a hydrocephalic brain in his laboratories at the Danvers (Mass.) State Hospital. Another Massachusetts hospital which attracted leading neuropathologists was the Worcester State Hospital and after working for three years in the West, Dr. Orton came there to serve as its pathologist from 1908 to 1912, following Dr. Adolph Meyer by a decade. During this period he also taught courses at the Harvard Medical School and at Clark University until 1913 when he arranged to go to Breslau, Germany, for study in the laboratories of Dr. A. Alzheimer.

Upon his return, Dr. Orton was appointed pathologist and clinical director of the Pennsylvania Hospital for Mental Diseases in Philadelphia where he was involved in many professional activities from 1914 to 1919. Although never a prolific writer, he usually managed to publish at least one scientific paper each year and the titles in his bibliography suggest the development of his interests during this period. (See Appendix.) Then came a move westward again with the opportunity to build and direct a State Psychopathic Hospital at Iowa City, Iowa, and head the department of psychiatry in the medical school of the State University of Iowa. There he spent the next eight years (1919-1927) and began his work with children with language disabilities.

Dr. Orton made sure that the new hospital provided ample space for his laboratories as well as facilities for the best care for his patients and he extended its services through an outpatient department with a staff which included psychologists, social workers, speech therapists, and others in related fields who worked with both children and adults. Courses were given to students in psychology, sociology and other departments of the University and consultations were held with many of the state institutions. Dr. Orton had always been active in promoting mental health activities, and in September, 1924, he presented a report at the Iowa State Conference of Social Work as chairman of the mental hygiene committee on "The Problem of the Feebleminded", covering in depth the social, legal, genetic, medical, psychological, psychiatric, and research areas involved. In view of his later work with children with learning problems, it is interesting to note that he stressed the fact that the so-called feebleminded were by no means a homogeneous group and urged the consideration of the individual's special abilities rather than his defects as a guide to his vocational training. At this same meeting, Dr. Orton proposed

"A Mobile Psychiatric Unit as the Most Feasible Method of Meeting Iowa's Mental Hygiene Needs." Four months later he was out in the field with such a unit conducting a clinic in Greene County, Iowa, upon the invitation of its local doctors, welfare agencies, and school authorities.

Thus the stage was set for the entrance of "M.P.", the sixteen-year-old youth from a rural school who was referred because "he seemed bright but couldn't learn to read", the prototype of the hundreds of other "word-blind" children to whom Dr. Orton was to devote the next twenty years, indeed the rest of his life.

"M.P." presented a special challenge to this neuropsychiatrist who was very familiar with the clinical symptoms and the brain pathology in adults who had *lost* their reading or speech through brain injuries — cases of acquired word-blindness, receptive and motor aphasia, etc., and Dr. Orton arranged to study the boy extensively at the hospital. The Greene County clinic soon discovered a number of other pupils who were blocked in their educational progress by specific retardation in learning to read. Dr. Orton became impressed by the extent of the problem, and particularly by the serious effect upon the personality development of children with this unrecognized and untreated handicap. His further studies of these cases led him to reject the older theories that some obscure brain defect or brain damage was the cause of "congenital word-blindness", as it was called, and he offered instead a physiological, functional explanation which carried with it a favorable prognosis. He saw in the reading disability a maturational deviation in language development which offered possibilities for specific remedial training and the relief of the emotional reactions in the children resulting from their anxiety and frustration. Noting especially their characteristic confusions in direction in their efforts to recall letters and words, he coined the term *strephosymbolia* (twisted symbols) to describe their difficulty.

Dr. Orton immediately envisaged in broad outlines a research program which was to extend far into future years and included: further investigation of the characteristic symptoms of the reading disability by controlled studies of larger numbers of children; experiments with teaching methods in harmony with neurological concepts — the therapeutic test; the extension of studies to related types of childhood language disabilities and apraxia, and underlying all, basic research in the physiology of the brain. Such a program was started the following year under his direction with a two-year grant from the Rockefeller Foundation (1926-1927) which also enabled the mobile mental hygiene clinics to continue. Comparative studies were made of the reading performance of a large sampling of normal and retarded readers from a variety of sources and a group with specific disability were successfully taught in a summer session at the hospital by his research associate in psychology, Miss Marion Monroe. Studies in stuttering were undertaken with Lee Edward Travis, Ph.D.,

a speech pathologist. Research in cerebral physiology was started on animals in his laboratories by a brain anatomist, with Dr. Lauretta Bender working on a correlated project in Holland. Lack of continuing research funds, however, prevented the fulfillment of this part of the program, to Dr. Orton's great disappointment, and together with certain issues over university policies, brought about his resignation from the hospital and the medical school in 1927.

The next twenty years of Dr. Orton's professional life were to follow quite a different course. Leaving the security of full-time hospital and medical school positions, he came to New York City in 1928 to open his own office for the practice of psychiatry. He was president-elect of the American Psychiatric Association in which he had long been active and he soon was given an appointment as neuropathologist at the New York Neurological Institute and a part-time professorship in neurology and neuropathology in the College of Physicians and Surgeons of Columbia University. Other responsibilities came with his election to the presidency of the American Association for Research in Nervous and Mental Disease in 1932 and continued editorial work on the *Archives of Neurology and Psychiatry* and the *Bulletin of the New York Neurological Institute,* which he was active in starting. But his interest in specific language difficulties persisted and in addition to seeing an increasing number of children with language and educational problems in his private practice, he was able to organize two more research programs, again with help from the Rockefeller Foundation.

The Language Research Project of the New York Neurological Institute was carried out under Dr. Orton's direction from 1932 to 1936, with a research associate in neurology the first year, Dr. Earl Chesher, and one in psychiatry, Dr. Paul Dozier, for the remaining time. A succession of assistants with training in various fields, mostly volunteers, made up the rest of the staff, with help for several months from Dr. Edwin Cole, a Boston neurologist. Diagnostic and treatment procedures were developed and tested with large numbers of children, and some adults, who presented a variety of language problems — reading, spelling, handwriting, auditory comprehension, speech development, stuttering, and certain language disorders associated with brain injuries. Although lack of funds and lack of space brought this project also to an untimely end, the knowledge acquired about language disabilities was widely disseminated through those who had participated in its program, developing in different ways in different places. Miss Anna Gillingham continued to consult with Dr. Orton on prediction and prevention experiments, and some ten years later she formulated her manual on remedial training with Miss Bessie Stillman. This she afterwards developed as the "alphabetic method" of teaching all beginning readers.

Dr. Orton's third research program, financed by the Rockefeller Foundation from 1939 to 1944, was directed toward further investigations of children

with special difficulty in learning motor skills, and involved slow-motion pictures and other studies of apraxia, carried out by Dr. David Wright at a boys' school in Connecticut. But this program was interrupted midstream by World War II. Dr. Orton's medical assistants went into military service and could not be replaced. He then transferred his research program to the Institute of the Pennsylvania Hospital in Philadelphia, making weekly visits there throughout the difficult winter of 1943-1944. One of the few gains from the wartime displacements was the coming of Katrina de Hirsch from England to New York City, where Dr. Orton found her experience with aphasic patients and her insights into the developmental language disorders of children a most welcome contribution to the field.

Dr. Orton once commented: "The physician brings to his task a feeling of personal responsibility to the patient indelibly impressed upon him as part of the heritage of medicine." (American Psychiatric Association presidential address, 1929.) This quality was outstanding in all of his work with the language disability children, together with his doctor's insistence upon a thorough individual diagnostic study before making any recommendations for treatment. A great deal of his time was devoted to conferences with parents and tutors and he worked incessantly to seek out and develop new resources to meet the educational needs of his patients, in schools and camps, in kindergartens and colleges. He gave talks to school faculties and parent-teacher groups, lectures to speech classes, courses for tutors and teachers, and seminars for the former members of his research staff, in addition to addressing many medical meetings in neighboring cities and states. Although he always declared himself unqualified to discuss general educational procedures for the average child, he did not hesitate to speak with authority about the responsibility of the educators as well as the doctors for "these certain children with certain developmental language disorders" and his very detailed, practical recommendations in written reports, conferences, and follow-up studies earned their respect and appreciation as he repeatedly demonstrated how the medical and the educational specialist could work profitably together for the benefit of the child. He also kept careful medical records with special attention to family histories on the 2000 or so private patients whom he saw during his twenty years in New York.

Most of Dr. Orton's talks were given from notes, often illustrated with lantern slides, and were not recorded, but some were transcribed in the proceedings of medical meetings or published in professional journals which provided reprints. These were useful in furnishing information about the language disabilities to his many correspondents from all over the United States and abroad and constitute the bulk of this present collection of his papers. When urged to write a book on language problems, Dr. Orton would always protest that he did not know enough about the subject yet, sometimes adding wryly, "Let my students do it." The book came about inadvertently, however, with the

Thomas W. Salmon Memorial Lectureship award in 1936. This entailed Dr. Orton's giving three consecutive lectures at the New York Academy of Medicine which were then printed by the lecture committee as a book of three chapters under the title, *Reading, Writing and Speech Problems in Children* (W. W. Norton & Co., Inc., New York, 1937).

Dr. Orton was married twice. His first wife, Mary Follett Orton, died in 1926, leaving him with three children: Samuel Torrey Orton, Jr. and Sarah Patterson Orton, twins, and Mary Follett Orton. He was married to June Frances Lyday of Detroit, Michigan, in 1928, at the beginning of his New York work in which she was thenceforth associated.

On the first of October, 1948, Dr. Orton announced his retirement from active practice, with anticipation of completing his country home, "Hwimsy", which he had enjoyed planning and building over a period of years. But during a visit there the very next day he suffered a fall, resulting in a broken hip and subsequent kidney and other complications. He was taken to St. Francis' Hospital in Poughkeepsie, New York, where he died six weeks later, on November 17, at the age of sixty-nine. Burial was in Columbus, Ohio, the place of his birth.

At a memorial dinner for Dr. Orton in New York City a year later, The Orton Society was founded by a group of his former associates and was dedicated to carrying forward the work for children with specific language disabilities in his scientific and humanitarian spirit.

June Lyday Orton*

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*Mrs. Samuel T. Orton (June Lyday Orton) is presently director of The Orton Reading Center, Winston-Salem, North Carolina.

Excerpts from

A MEDICAL TRIBUTE

By

JOHN M. DORSEY, M.D.*

SAMUEL TORREY ORTON, MEDICAL EDUCATOR

" . . . His very appearance was notable — tall, lean, fine looking, good natured, quick, alert, buoyant, dignified, gallant, economically energetic, enduring. His large, gray, calm, kind eyes were seeing eyes. He spoke ever as one of authority and made his subject live by putting himself into it. His deep resonant voice was one to remember. It could drawl, it could snap, it could sing. He carried himself with the easy assurance of an athlete. At rest his manner and posture were natural and relaxed. He had a very attractive social side and generously opened up his home for many enjoyable occasions. (His favorite songs and sure impromptu guitar playing seemed to charm every visitor into accompanying him. Who could resist his musical treatment of "Abdul, the Bulbul Amier" and "Ivan Petruski Skavor"!)

" . . . When I became a medical student at the State University of Iowa in the fall of 1921, I heard my fellow medics speak of the wonderful clarity, marvelous diction and erudite view 'for the whole field of pathology' with which Dr. Orton conducted his laboratory and classroom work. He enjoyed the medical student's fond appreciation particularly on account of his fairness and warm student identifications. His earnest interest in, and devotion to, his responsibilities as professor and chairman of his department of psychiatry were outstanding. In the neuropathology laboratory, at hospital rounds and clinical conferences, in the machine shop which he maintained for converting his ideas directly into practical instruments, — everywhere — his was the acknowledged genius of the place.

" . . . During my senior year in medicine occurred the event which decided the course my professional life was to take. Dr. Orton described for me the

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*Dr. Dorsey received his A.B., M.D., and M.A. degrees from the State University of Iowa and completed two years of study at the Viennese Psychoanalytic Institute. He served as Chief of Staff at the Iowa State Psychopathic Hospital and head of its Mobile Mental Hygiene Unit. He has also been associated with the University Medical School and the State Psychopathic Hospital in Ann Arbor, Michigan, and its affiliates in Detroit where he has been outstanding in mental health activities, medical education and research for many years. Dr. Dorsey is presently University Professor at Wayne State University where he formerly was chairman and professor of the department of Psychiatry. His many publications include "Foundations of Human Nature" (1935) and "Elementary Medical Education" (1965).

tremendous importance of the discipline of psychiatry and the future to be expected of it. Setting slight value upon so-called 'wealth', he proceeded to point out for me some of my expressed aptitude for mental discipline and indicated that he would accept me for psychiatric training . . . It took very little making up of my mind and I have never felt other than fortunate about my quickly definite decision . . . How I applied myself during my psychiatry residency to be sure of my physical and laboratory findings! It was imperative that my neurological findings be full, my bio-chemical studies be thorough, and my psychological work-up be profound. Through Dr. Orton I first made myself knowledgeable about the meaning of *self-insight,* a term which has proved the most help of all of my psychiatric vocabulary.

" . . . It was always a thrilling experience to have Dr. Orton start out with me in the laboratory, whether preparing tissues and selecting stains or reading action current films. Then and there his germinal mind found apt expression in its capable hands and he showed his love of function generally. His matter-of-fact manner always respected the fact . . . His appreciation of achievement, especially the operation of free creative intelligence, was always evident . . . During my years of collaboration with him (for his staff orientation was always one of equality), he consistently stood fast for academic freedom, for the autonomy of his every worker. Each one asked for and received his undivided penetrating attention.

" . . . The terms 'functional' and 'organic' had widespread usage in the days of my beginning psychiatric training. No question about it, my chief was a downright and forthright organicist. Gradually I came to understand that respect for organicity was his trustworthy way of upholding his all-important truth of individuality. Whatever was the matter with his patient, the trouble could be found only *in* his patient — not in some kind of 'relationship between' his patient and somebody else . . . He considered himself a 'neuro-psychiatrist', one who studied and treated mental disorder in terms of the whole individuality of the patient only . . . How often I have thanked myself for the good sense I used in taking advantage of his kindly proffered 'psychiatric training' . . . How gladly I think to myself: my Dr. Orton, my first chief, was a scholarly medical educator of the first rank of merit: individuality-conscious, study-minded, honor-bound . . . He underwent many a severe life trial, including extremely painful health ordeals, yet kept on working to the end . . . Tennyson's insightful verses relate of him all that I can:

> Self-reverence, self-knowledge, self control,
> These three alone lead life to sovereign power."

December 16, 1963 J.M.D.
Wayne State University.

Reprinted from PSYCHIATRY AND THE WAR, Ed. Frank J. Sladen, M.D.
Charles C. Thomas, Springfield, Ill., 1943

THE PHILOSOPHY OF PSYCHIATRY:

REMARKS

by

SAMUEL T. ORTON, M.D.

at

McGREGOR FUND AND UNIVERSITY OF MICHIGAN SYMPOSIUM

Ann Arbor, Michigan, October 24, 1942

DR. SAMUEL T. ORTON: I do not feel that I am equipped to speak on the Philosophy of Psychiatry, particularly when included in a session under the leadership of Dr. Meyer who is so well prepared for such a task. However, I have been a close observer of the trends of thought which have influenced the development of psychiatry for about thirty-five years and actively at work in certain phases of its field during the same time. This period has been one of marked change in emphasis among psychiatrists and of marked expansion in their fields of interest and endeavor, and I hope that a brief review of my observations during that time may prove of interest.

While still a medical student I became interested in pathology, and on graduation I was fortunate enough to be accepted for a period of training under one of America's best teachers of general pathology, Dr. Frank B. Mallory, at the Boston City Hospital. At the end of that service an opportunity was offered to me in neuropathology, and I spent a short time adding a knowledge of the special techniques of this field and in becoming pretty thoroughly familiar with the problems of cerebral localization under the guidance of Dr. E. E. Southard at the Danvers State Hospital in Massachusetts. Those who had the opportunity of working under Dr. Southard will appreciate how much stimulus and enthusiasm he was able to inject into all of those who had the good fortune to serve with him.

Thus I started with unusually good preparation, and it was a period when neuropathology was thought to offer as much promise in the field of mental disease as its parent subject, general pathology, had held for the somatic diseases. Nisel's method for staining the extra-nuclear chromatin granules in nerve cells was comparatively new and Nisel and Alzheimer had described the histological changes in paresis and had given for that one mental disease a definite diagnostic criterion. This led to the hope that new methods of staining and finer histological detail would in time reveal structural alterations in other

diseases. The older explanations of insanity as being due to magic, the influence of evil spirits, and over-exposure to moonlight had dropped out and the new science of neuropathology was considered the most promising field of exploration.

It was only shortly thereafter, however, that the swing away from the organic or structural causation toward that of functional disorders began to be apparent. There were two reasons for this change. First, the structural attack was not so productive as had been hoped, and it gradually became obvious that the brains of about 80% of our admissions to the state hospitals did not show organic changes pathognomonic for the corresponding clinical pictures; and second, new concepts of the importance of disorders of function began to bear fruit. On the first or negative side of the picture stood such work as that of Dunlap who, after several years of intensive study of the brains of cases of dementia praecox, reported that not only could he find no distinctive pathological picture in them but he could find no way in which they differed from the brains of nonpsychotic individuals. The second or positive side was supported by the studies of Freud and Jung and their pupils. Freud and Jung were at that time sufficiently in agreement to appear on the same platform, and the series of lectures which they gave at Clark University on the invitation of President G. Stanley Hall gave added impulse to the swing of the pendulum toward a functional explanation of many phenomena.

While recognizing the importance of the emphasis so placed on the enormous part played in our behavior by our instincts and emotions, I think it may be fairly said that the swing went to the extreme and gave us a whole generation of psychiatrists who had not even a nodding acquaintance with the structure of man's brain. The discussions at that time would, I think, bear me out in that. There was a great deal of talk about the possibility of lay analysts handling psychotic cases as well as borderline ones, and I even heard a very active and somewhat acrimonious discussion among one of the leading groups of the American Psychiatric Association as to whether we ought not to relegate all the organic psychoses to be studied exclusively by the neurologists, i.e., to group together with the spinal cord and midbrain diseases all that showed a lesion of the brain or cortex, and confine our own interests to the so-called functional groups. The continuation of the study of the brain, of its structures, its functions, and to some extent of its changes and alterations, was turned over during that period very largely, except for a few of us who maintained our old interests, to the physiologists, to the brain surgeons and even to the psychologists.

Another movement which began at about that period was the development of the psychopathic hospital. It had been recognized for some time past that the state institutions, while fulfilling the custodial need very well for the most part, were not the place for the best possible treatment for acute psychotic

cases and particularly for borderline cases. Also, there was need for institutions that would segregate the more interesting material for research so that it would not be lost in the maze of large ward groups, and for the expansion of the teaching facilities. These three needs — that of a hospital for treatment, selection of cases for research and of material for teaching — led to the establishment of the genuine psychopathic hospital. Many institutions which were merely receiving hospitals subsequently borrowed that title but were not covering the whole field. The first of the genuine psychopathic hospitals was established here in Ann Arbor under Dr. Albert M. Barrett. Your City and your University may rightly claim to be the pioneers in that regard. The second followed relatively shortly after, with the development of the Phipps Clinic under Dr. Adolph Meyer in Baltimore. The third was that of Dr. Southard in Boston, and it was my good fortune to organize and direct the fourth unit, in Iowa City.

Another movement of about the same time was the tendency toward extension of psychiatric work through mental hygiene societies and mental hygiene clinics. In Iowa we made an experiment in this direction at, I think, quite an early date. Our original experiment was carried out by a group of us from the Psychopathic Hospital staff who had volunteered to go to any community in that state which wanted us and to study cases referred by the doctors, by the courts, by the county social agencies and finally by the schools. We felt we could offer service to these various agencies since our unit was made up of a psychiatrist, a psychologist and a trained psychiatric social worker. The yield was very good, I believe, and we were able to extend it, through a liberal grant from the Rockefeller Foundation, to an enlarged two-year experimental period with the Mobile Mental Hygiene Clinic, as we called it, moving from city to city through the state and studying intensively on the ground, the cases that were referred to us, rather than having them sent to the Hospital in Iowa City.

There was also a growing tendency toward extension of psychiatric interest into the period of childhood, which Dr. White so aptly spoke of as the "golden period of mental hygiene." I think also it was a golden period for research of various types. The interest in children's work has spread very widely and is still actively enlarging. Still more recent is the broadening interest in the application of psychiatry to sociology, both to the understanding of how social factors affect the psychotic disturbance in a given individual and also the influence that psychotic ideas and psychopathic personalities, particularly when they occur in natural leaders of men, may have on society at large.

When I began work at Danvers, Dr. Southard introduced me to a recent book and suggested that a study of the brain of an extreme case of chronic internal hydrocephalus along the same line might be interesting. It was Campbell's Histological Localization of Cerebral Function, and it was, I believe, the

first complete map of the human brain based on the histological differences between various areas. This book was followed shortly afterward by much more extensive works by German writers, one of which has since become the popular guide to which to refer in identifying given cortical regions. Campbell's work was much simpler but at the end of the description of each cortex type he reviewed the evidence concerning its function, and it forms, I believe, a much more serviceable chart for correlation of clinical findings. His successors have carried the separation of areas showing minor differences in cellular and fibrous architectonics beyond our ability to subdivide functions with security.

I have carried Campbell's map and its interpretations in mind ever since and have applied it extensively in interpretations. I cannot emphasize too strongly my belief that the enormous organ which evolution has developed in man's head has a much wider part to play in his behavior than that of a generator of emotions, and that a thorough knowledge of the functions represented in each of the various large areas which show a markedly different histologic structure is of enormous value in the study of many clinical syndromes. Moreover, I believe not only that emotional variations may modify the efficiency of the various brain functions, but also that differences in physiological activity of specific areas may generate emotional deviations as well, and that thus observed concurrent emotional disturbances may often be an effect rather than a cause of disordered functions.

One of the best illustrations of this relationship is, I think, to be seen in a critical study of the earliest stages of stuttering — a disorder which frequently makes its first appearance in childhood. When stuttering is studied in an adult who has labored under this handicap all of his life, many neurotic traits are seen which are not obvious in childhood and may quite logically be explained as the results of experience — for example, the withdrawal from social contacts and the avoidance of other situations which require fluent speech — thus fear of the telephone which is a frequent finding in adult stutterers may be a result of past difficulties with that instrument rather than a phobia which causes the stuttering, as it is so often interpreted. Stuttering children, early in the course of their trouble, do not avoid social contacts nor do they fear the telephone, and they do not as a group show any consistent apprehensiveness which might be considered a constitutional factor sufficient to explain the later development of phobias. Indeed many of these children are of a distinctly social, garrulous and venturesome make-up, both before and immediately after the onset of their difficulty. They often exhibit reactions to frustration, when their attempts to speak are blocked, but this would seem to be an entirely logical behavior reaction. Stuttering may, of course, occur in a true neurotic individual, as would be expected in any group selected by including those showing one given type of disorder, but our observations in children have led me to believe that a marked injustice is often done when the presence of stuttering is accepted as *prima facie* evidence of the existence of a neurosis.

In the course of an extended program of research covering a period of about seventeen years, I have also become convinced that certain developmental disorders in childhood may rest not on structural alterations of a given area of the brain but on a failure to acquire the normal physiological pattern of action of that area. This rests partly on our studies of the reading disability — strephosymbolia — and the very close parallel which exists between its symptoms and those seen in acquired alexia in the adult, and partly on the extension of these studies to the problems of developmental aphasia and developmental apraxia. This last syndrome is still a research problem and our most thorough piece of work on it has not as yet been published.

The reasons for accepting a physiological hypothesis concerning the developmental delay of childhood are too varied and too complex to go into in detail within the time allotted here but suffice it to say that they seem to harmonize with modern neurological opinion and to take cognizance of both the intrinsic or hereditary factors and the play of extrinsic or environmental factors and finally to meet the therapeutic test of response to proper retraining methods. While the determining factor seems best explainable on the basis of a faulty physiology we must, of course, grant the emotional factors a prominent place in the picture. I believe that the interplay between these two must always be taken into account. We can no more isolate one from the other than we can discard either the warp or the woof of a piece of cloth. With either gone it is no longer cloth.

Finally, in closing, since our studies point to a failure to acquire the normal adult pattern of unilateral cerebral dominance as the source of the developmental language disorders and of developmental apraxia and since the pattern of control from one side of the brain is also disturbed in injuries to critical areas of the dominant hemisphere, we are hopeful that the somewhat better understanding of the principle of unilateral dominance gained in our studies of the special disabilities of childhood and the methods of retraining derived therefrom which have been so effective, may prove helpful in the rehabilitation of cases with war injuries of the brain. [World War II] We are convinced, as outlined above, that the classifying of all stutterers as neurotics is an error and the assumption that non-readers are mentally defective can be readily shown to be untenable and we feel sure that some of our observations on right-brained (left-handed) children and on those with mixed or confused dominance could profitably be used for better understanding the troubles which lead, in the Army, to the awkward squad or to the failures of a strongly left-eyed soldier in the rifle pits and that such understanding would in turn be serviceable in the proper assignment for service of these men who do not conform to the more common pattern.

Reprints of Papers

on

Developmental Language Disabilities

by

Samuel T. Orton, M.D.

Reproduced from manuscript by Samuel T. Orton, M.D.
(reduced in size)

Strephosymbolia.

a "temporal cross section" of the theory of reading disabilities as of July 1925.

... Thus strephosymbolia would be envisaged as of no relation to right and left handedness in the ordinary sense (though it may prove to be more common in the left handed) nor to the question of fixed dextrad or sinistrad orientation of written languages but rather as due to a failure to establish an exclusively unilateral dominance by adequate training for elision of obverse sensory engrams so that in using visual material from the associative level the lead is an inconsistent and confusing one.

Samuel Torrey Orton.

July 12th 1925.

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"WORD-BLINDNESS" IN SCHOOL CHILDREN *

SAMUEL T. ORTON, A.M., M.D.
IOWA CITY

The material included in this preliminary report has come from several sources but was assembled chiefly during an experimental clinic held by members of the Iowa State Psychopathic Hospital Staff in Greene County, Iowa, in January, 1925. Among those children who were reported to the clinic by their teachers as "dull, subnormal, or failing or retarded in school work" was a fairly high proportion whose chief difficulty was in learning to read. Two of these would fit Hinshelwood's criteria of true "congenital word-blindness," and one of these two cases (M. P.) also gave bizarre written productions.

Because of his striking disability, M. P. was admitted to the State Psychopathic Hospital, and his case was there studied more thoroughly than was possible in the clinic. The results of this study are here reported in full.

Observations suggesting an explanation of one of the factors in this case are recorded from other cases. These were the presence of mirror reading, mirror writing and a strong tendency to attempt to read parts or all of a word from right to left and confusion of those letters in which orientation is essential.

Only a few of the studies from the literature of mirror writing and left-handedness have been reviewed in preparing this preliminary report, but these indicate the great frequency of these conditions in "defective" children. The method of writing in alternate directions and with the letters correspondingly oriented as seen in certain ancient documents indicates that our present method of dextrad writing with single orientation of letters has been arbitrarily fixed by custom.

The views on "congenital word-blindness" in the medical literature seem untenable as an explanation of these cases. An hypothesis more in harmony with present conceptions of the aphasias and based on the structural relations and the probable physiologic activities within the visual cortices of the two hemispheres is offered, and a new, descriptive term is suggested for this group.

Some points of psychiatric import are suggested. Certain reactions to the disability might readily serve to establish determining character traits. Moreover, it seems probable that psychometric tests as ordinarily employed give an entirely erroneous and unfair estimate of the intellectual capacity of these children.

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* From the laboratories of the State Psychopathic Hospital, Iowa City.

* Read at the Fifty-First Annual Meeting of the American Neurological Association, Washington, D. C., May, 1925.

The implications from the standpoint of education are challenging. If the views herein expressed are proved to be correct by further observation and experiment, there is reason to believe that the majority of these disabilities can be entirely overcome by special training. The methods of training, however, must be developed in consonance with the neurologic background and tested by carefully controlled experiment.

SOURCE OF AUTHOR'S MATERIAL

During two weeks in January, 1925, a mobile mental clinic [1] was held as an experiment in Greene County, Iowa, by a group of members of the staff of the State Psychopathic Hospital, consisting of the director of the hospital acting as psychiatrist, the chief social worker of the hospital, a graduate student assistant in social work, the hospital psychologist and a graduate student assistant in psychology.

Cases were referred to this clinic by four agencies in the county—the physicians, the county attorney, the secretary of the social service league and the schools. An announcement was made to the school teachers that the clinic would be ready to study pupils who seemed unusually bright, and in whom the question of double promotion or enlargement in scope of the school work might be indicated, pupils who presented behavior problems and those who were considered defective or who were retarded or failing in their school work.

This last group, the retarded, the failures and those considered by their teachers to be defective, proved to be an extremely interesting selection. Altogether 142 pupils of the grade and high schools of the county were studied. Eighty-eight of the 142 fell in the group referred by the teachers as deficient. Psychometric ratings were made of eighty-four of these, but they did not agree closely with the teachers' estimates of the children's abilities.

The distribution of this group by psychometric ratings obtained by individual Stanford-Binet tests was as follows:

TABLE 1.—*Psychometric Ratings of Eighty-Four Deficient Students*

Very superior intelligence, Stanford-Binet Test, intelligence quotient, 120 or over.	1
Superior intelligence, Stanford-Binet Test, intelligence quotient, 110 to 119....	0
Average intelligence, Stanford-Binet Test, intelligence quotient, 90 to 109.....	31
Dull normal intelligence, Stanford-Binet Test, intelligence quotient, 80 to 89....	20
Marginal defective, Stanford-Binet Test, intelligence, 70 to 79.....	18
Moron, Stanford-Binet Test, intelligence quotient, 50 to 69.....	13
Imbecile, Stanford-Binet Test, intelligence quotient, 25 to 49.....	1
	84

1. To be reported in greater detail elsewhere.

It is obvious from this distribution that other factors than mental defect were largely responsible for the poor work of these children. Among these factors appeared a special difficulty in learning to read. Fourteen of these eighty-eight children were reported by the teachers as having great difficulty in learning to read, or were seen by their grades or by cursory examinations in the clinic to have some special limitations here. One other student referred by his teachers as "nervous" proved to be of this type. Because the method of selection did not specifically call for those with reading disabilities, it is highly probable that this number does not adequately present the whole problem in these schools.

The distribution by grades and intelligence quotients of the fifteen who were recognized as having this disability in greater or less degree was as follows:

TABLE 2.—*Distribution by Grades and Intelligence Quotient of Students with Difficulty in Learning to Read*

School Grade	Case	Stanford-Binet Intelligence Quotient
First	Merle	103
Second	Dale	91
Second	Francis	122
Second	Douglas	92
Third	Clarke	102
Third	Ludlow	105
Third	Etta	91
Third	Wayne	96
Third	Karl	99
Third	George	75
Third	Derald	102
Seventh	Donald	70
Eighth	John	72
Ninth	Jack	85
Ninth	M. P.	71

The two outstanding cases were those of boys about 16 years of age, who had reached the ninth grade, and the degree of their disability was so extreme as to warrant their inclusion in the group of cases described by Hinshelwood [2] under the name of congenital word-blindness. In addition to a practically complete inability to read, one of these two boys (M. P.) had submitted some extremely curious productions as written exercises in school.

STUDY OF A TYPICAL CASE

During the clinic, M. P. was tested by the Stanford-Binet method and showed the following rating: Age, 16 years, 2 months; mental

2. Hinshelwood, J.: Congenital Word-Blindness, London, H. K. Lewis, 1917.

age, 11 years, 4 months; intelligence quotient, 71. During the psychiatric examination which followed, however, I was strongly impressed with the feeling that this estimate did not do justice to the boy's mental equipment, and that the low rating was to be explained by the fact that the test is inadequate to gage the equipment in a case of such a special disability. Further, it was easily seen that while he was unable to recall the visual impressions of words clearly enough to recognize them in print, he did make facile use of visual imagery of objects of rather complex type. I asked him, for example, questions concerning the

I. Comter in 1777.
The Enlgand camele stosent in cane hosterson the their last scoune and honeter posterson and rososon and sean 1000 scouter then to pastore and the fosteron the secounter tall theen heuster and at dog befor mostir hasden or Miss Hesant well be a wholl and the stosert heute Capuster and Husglas suerist to Austerson. Scallson stosert of Kronton and uester to called stosert to counter and cane to the scoperson cane doses the toster of the coster of the Boster and teter to last scastorn and to nicast to. But the Anson custome stosent tae the the cashie so the peoper sconer tabe at his the usenter eacet.
Desless of faster to the Last of the scomet of caperson tall the and there can to last a burst Uster and heust Lester and cane to the art last.

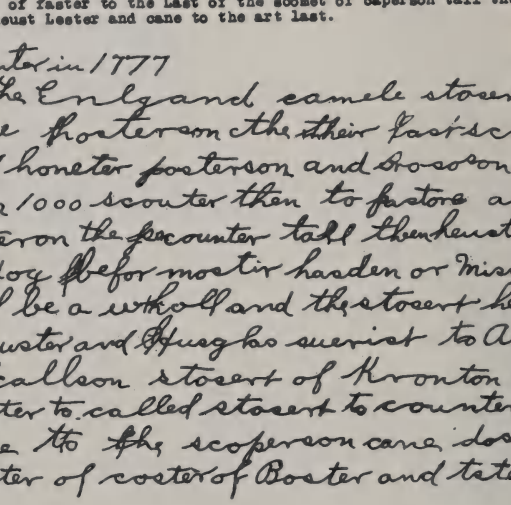

Fig. 1.

adjustment of bearings in the V type automobile engine which required a good visualizing power for answer, and his replies were prompt and keen.

Figure 1 gives above, a transcript of a page of one of his written productions, and below, a part of it in fac-simile. This was submitted as a composition in American History describing the English Campaign of 1777.

The challenge to interpretation contained in this production, together with the doubts of the accuracy of his mental rating and the general interest of the reading defect, led to his admission to the psychopathic hospital for more extended study and experiment.

Additional tests given in the psychologic laboratory of the hospital gave the following results: The Stanford-Binet test was repeated, but certain alternative tests were substituted; others, when permissible, were given orally, and he was tried by tests higher in the scale. This resulted in a mental age of 13 years, 10 months, and an intelligence quotient of 86—fifteen points higher than in the initial test, thus placing him in the dull normal instead of the marginal defective group. He still gave the impression, however, to one who had learned to estimate mental defect before the widespread use of mental tests, of a much better equipment than even this second rating indicated. By the Pintner-Patterson performance tests, his accomplishment was satisfactory for adults. On twelve of the twenty-two items he earned maximum scores. By the Healy pictorial completion test No. 2 his score was 90 out of a possible 100, which is a superior performance for adults. By the Stenquist mechanical assembly test, No. 1, he earned a score of 82, which would place him on a level with the highest 1 per cent. of unselected army draft recruits. He solved the Freeman mechanical puzzle box in 102 seconds on the first trial and 72 seconds on the second, which is a superior performance. Tests with Nagel's color blindness cards gave no evidence of defect in color vision. His capacity to read in a mirror was tested, and it was found that this reversed presentation made no difference in his ease of reading.

As the next step in the study of his case, he was tried repeatedly by the series of tests devised by Head [3] in his studies of aphasia. The tests of capacity to draw and of the mimeokinetic functions with and without the mirror were tried briefly. The others, however, were carried out repeatedly, and as a result it was obvious that there was no difficulty in the recognition of objects or in calling them by name when visually presented, or in indicating an object by pointing when its name was called. He recognized all of the letters of the alphabet and the arabic numerals promptly, and called each by name correctly without hesitation. When names of objects were visually presented, however, there was prompt and correct response in only a few instances, and these usually only in the case of the simplest words. With the longer and less simple words there was delay with evident effort to spell out the word and vocal or subvocal attempts at pronunciation of its letters and syllables, with varying degrees of success. This presentation of words was carried out in three forms: in script, in typewritten words and by means of black paper letters one quarter of an inch high mounted on white cards. There was no great difference in the ease of reading of any of these, although the gummed letters on cards seemed a trifle easier for him.

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3. Head, Henry: Brain **43**:2, 1920.

He was then tested for his capacity to copy in script from printed text with the result shown in Figure 2.

It will be noted that while there is a certain immaturity about the writing, it is by no means a bad production for a 16 year old boy, and that the copy is practically letter perfect. When asked, however, for the content of what he had just copied, he replied: "I don't know, I didn't read it." He was then asked to read it from his own handwriting, and his pronunciation, reproduced as accurately as I could record it, is shown at the bottom of Figure 2. He produced this slowly and with obvious effort, and in the case of most of the words by sounding out part or all of the individual letters before attempting to pronounce the word as a whole. The similarity of syllabic structure of some of these

COPIED FROM TEXT

The plant consists of twelve separate buildings
most of which are new located in the midst of a
beautifully shaded fifty-acre lawn surrounded
by a hundred and twenty-acre tract of land.
Remoteness from any neighbor assures absolute
quietness

When asked for content he replied - "I don't know - I didn't read it".

READING ABOVE FROM OWN COPY

The prant side of (sounds t-w-e-l-v-e but pronounces)
twevel separated building mest of which are near located in
the mist of a boosefer - booseful should fifty acres lone
sardoned by a handered and ten - tendered - acres track of
long land.

Fig. 2.

words to that of the neographisms in his original composition (Fig. 1) is apparent. He was then asked to read the same material from the original printed text, and while his errors were not quite the same, the general character was quite like that from his own copy of it.

A copy of a children's edition of "Aladdin and the Wonderful Lamp" was then given him with instructions to read the first page aloud. His efforts at this are shown in Figure 3. The text is given at the top of the illustration; next is my record of his reading. He was then asked to write the same material from dictation (given two or three words at a time), and a copy of this production forms the third part of the illustration. After he had attempted to read this material and then had written it to dictation, he was asked to reproduce its contents from memory. The result is recorded at the bottom of the illustration. When questioned as to his inability to remember the

material, he replied: "It takes me so long to spell out some words that by the time I read them I forget what was ahead of them."

To test his auditory memory the second page of "Aladdin and the Wonderful Lamp" was read aloud to him, and he was instructed to listen and be prepared to repeat the story. The text was:

"How would you like to work for me, my boy? I will pay you well," he said to Aladdin. Aladdin said nothing would please him more if his mother would let him.

The poor widow was overjoyed to have Aladdin make some money, and he started next day to work for the magician who treated Aladdin very kindly, giving him lots of fine clothes and paying him well.

Everything went well until one day the magician said to Aladdin: "Come, my boy, I will take you for a walk and show you some very fine things."

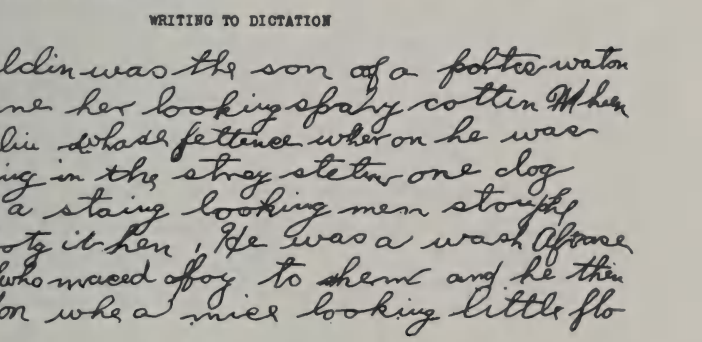
TEXT

Aladdin was the son of a poor widow who made her living spinning cotton. When Aladdin was fifteen years old he was playing in the street one day when a strange-looking man stopped and looked at him. He was a wicked African magician who needed a boy to help him, and he thought Aladdin was a nice looking little fellow.

READING (Time 6' 10")

Aladdin was the son of a poor woman who made her livin spinning cotton. When laddin was fighting were old he was playing in the street one day when a standar looking man stepped up and looked at him. He was a wicked African macrican who nidded - needed a boy to help him and he took Aladdin with a nike looking little flume.

WRITING TO DICTATION



REPRODUCTION OF ABOVE AFTER READING AND WRITING

There was Aladdin. His mother took in wash - I mean - knitted wool - I mean cotton and he was playing in the street one day and a cross African man rode up and he thought he was good looking so he took him with him.

Fig. 3.

M. P.'s reproduction of this was:

He asked Aladdin if he would like to work for him and said he would pay him. Aladdin said he would if his mother would let him. His mother was glad to have him earn some more money and he went to work for the *musician* who bought him some clothes and paid him. Everything went alright until the *musician* asked him, "When will you take a walk *in the woods* with me and see some fine things?"

It will be seen that this is quite a creditable reproduction of the content of the presented text. Two errors appear—"magician" becomes "musician" and the phrase "in the woods" is inserted.

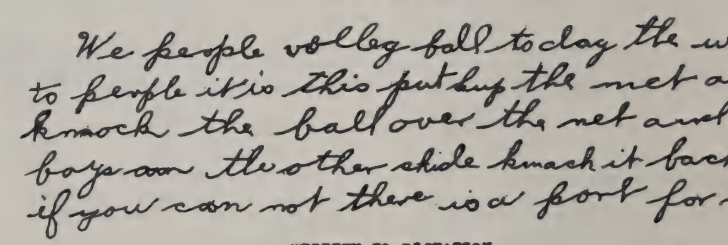
He was next asked to describe in his own words some of the events of the hospital day, and then to write them down. Figure 4 gives above his verbal description and below a fac-simile of his writing of the same material, and at the bottom, of his production on writing to dictation.

Several words were next dictated, first as words and then letter by letter, and a written record of them was requested. The whole words were better written than when spontaneously done, and when spelled out letter by letter slowly enough for him to write each letter before the next was heard, he wrote them perfectly. When, however, all the letters of a word were verbally given and he was instructed to wait until the

VERBAL DESCRIPTION

We played volley ball today. The way to play it is this - put up the net and knock the ball over the net and the boy on the other side knocks it back and if you can not there is a point for him.

WRITING ABOVE


We people volley ball today the way
to people it is this put up the net and
knock the ball over the net and the
boys on the other shide knock it back and
if you can not there is a port for he.

WRITTEN TO DICTATION

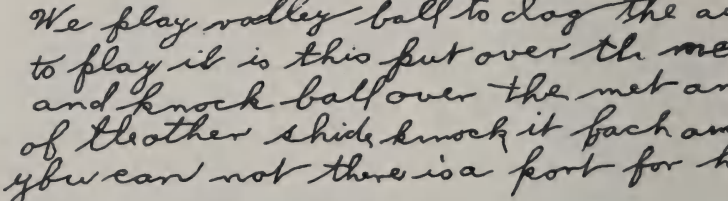

We play valley ball to day the awaye
to play it is this put over the net
and knock ball over the net and boys
of the other shide knock it back and if
ybu can not there is a port for he.

Fig. 4.

word was spelled completely before beginning to write, his attempts at writing were again full of errors, suggesting an extremely short memory span for series of letter sounds. His span for numerals in other tests was variable, but much better than that indicated for letters.

A large series of separate words made by gummed letters on cards was then prepared, and his ability to read these was tested. Many of these formed series of similar words, such as: mare, fare, bare; mend, rend, tend; lack, back, hack; etc. Others were longer common words, like tonight, today, tomorrow, and some were two-syllable words in a series, like target, tarnish, tardy, etc. These two-syllable words were presented as units and also separated into syllables. Altogether, about

250 cards were used in various ways. Reading of two-syllable words was definitely easier when the syllables were separated, and some words which were impossible for him to read as a whole could be made plain for him by building them letter by letter, using letters mounted on blocks (anagrams). In going over the same series of words day after day, some distinct facilitation was observed, and yet this was irregular, and often words remembered from one day to the next were missed when re-presented on the third day. In one series of sixty-nine simple words, none with more than two syllables, after taking all the time desired for spelling out and corrections, he read only thirty-two correctly.

Recognition of the letters of the alphabet was immediate always, and the name of each letter was correctly and promptly given. When, however, he was asked to sound out the letters as presented, there was evidence of a striking lack of association of certain letter sounds with the corresponding letter form. All of these sounds were possible for him, and were consistently used in speech, but when a certain printed vowel was presented to him, usually only one of its varied sounds came as a spontaneous response. When pressed for other possible sounds, after considerable hesitation, he usually would offer another; but some of the common sounds of vowels were never produced as a response to visual presentation of the corresponding letters standing alone, although in short words which he could read at sight, he often used all the sounds of each vowel. In the first column of the following table are shown the letters visually presented; in the second, the sound response immediately offered; in the third, the response in answer to the question as to whether this letter might have other sounds, and in the fourth, the common sounds of the letters which were never produced as a spontaneous or requested response to the letter standing alone.

TABLE 3.—*Letter Test*

Letters	When Read	When Questioned	Not Produced
a	ă	ĭ	ā ä*
e	ĭ	ē*	ĕ*
i	ĭ	ī (slow)	.....
o	oo	.....	ō*
u	yŭ	ŭ	ū
y	wŭ	wĭ	ī* ĭ
w	wŭ	.....	.....
c	k	s (rare)	.....

* These sounds were frequently reproduced in short words which he could read at sight, such as me, bet, my, old, farm, etc.

The effect on his reading of this faulty range of sound associations with certain letters is seen in Table 3.

TABLE 4.—*Word Test*

Word Presented	Read as
Child	Chĭlled
Chilly	Chĭlwŭ
Twenty	Twĭntwŭ or twentwŭ
Blue	Blwŭ
Ball	Bĕll, bĭll (various times)
Tend	Tĭnd
Dug	Dwŭg
Check	Chŭck
Chock	Chŭck
Bend	Bĭnd
Nice	Nĭke

The second noted element was a tendency to reverse parts or all of a word and read the letters from right to left. A few examples of this follow:

TABLE 5.—*Word Test*

Word Presented	Read as
Dug	Gud
Gray	Gary
Tar-nish	Tar-shin
Pardner	Ponder
Mend	Medn
Fend	Fedn
Tomorrow	Tworrom

Both of these factors may be seen operating together in such pronunciations as: twĭvl for twelve, rĭdn for rend, tĕgrĕt for target, blĕwŭ for blue, etc.

A considerable series of three letter nonsense syllable was also presented by means of the anagrams and gummed letters. In this experiment he was told not to try to find a word with meaning but simply to sound the letter groups as they looked to him, and here again the two elements in his disability mentioned above became evident. Again when trying to read there was a striking tendency to get the sound of a few of the initial letters and then to "jump" at the rest. Blue was frequently read as black or blow. When check was presented, he first read it as chick. Chick was then presented and correctly read, but when check was again presented it was read first as cheek, then chuck, then choke. This tendency was much more pronounced after the tests had been under way for a short time, and apparently increased with fatigue.

In his attempts at writing there was also frequent elision of letters resulting in phonic simplifications, which were frequently readily understandable although bizarre in appearance. Work-up became wrkp, supper became supr, dining-room became dierom, cargo became crgo, etc. Several grades of error in writing were observed. Some might

rank as extreme instances of misspelling, as blou for blue, weit for white, blak for black, etc. Others show the substitution of other words with similar initial letters, as people for play, port for point, looking for living, etc. Still others show distortions which have almost or entirely lost their sound relation, as hlo for yellow, gen or green, waton for widow, spary for spinning, feltence for fifteen, etc. The number of neographisms in any written production seemed to be in indirect relation to the degree of effort expended, and hence to the speed of production. When M. P. was urged to take the time he needed and spell out each word, the product was very much better than when he was told to write rapidly, but some errors crept in even in his most careful work, and such productions were an exceedingly slow and arduous task. Fatigue effects appeared early in these efforts, and apparently served to increase the production of bizarre words. There is a striking tendency in his composition (Fig. 1) to repeat new words of almost similar form, such as hosterson, rososon, fosteron, scoperson and toster, coster, Boster, tster, etc. There was also in his reading of a series of words from cards a noticeable perseveration of letters. Bend was called bĭnd, and when followed by lend, the latter became blĭnd; rend was called rĕdn, and when followed by send, the latter became srĕdn, etc. This tendency was never observed when the first word was one which he knew and recognized at sight, so that it seemed as though the unsolved puzzle of a word which did not bring its proper sound association continued its influence on the next presented. The striking neographisms which characterize Figure 1 can probably never be interpreted, as M. P. himself has forgotten the details of the campaign which he had in mind when this was written.

A few brief experiments were tried in training M. P. to learn to recognize some of the simple words that proved hard for him. Twenty was one of these, although he read it promptly as twenty if spelled t-w-a-n-t-i. Twe was presented, and he pronounced it twē. When urged to try another sound for the e, it was produced as twĭ. The twĕ sounds were then pronounced for him, and tweh was presented and read as twēn. On urging, it was finally produced as twĕn, and then twent was offered. This was pronounced as twĕnt, but when the y was added it was pronounced as twentwŭ. Y was then pronounced for him as ĭ, and he was drilled with ly, ty, and ry, etc., and again twenty was presented, and this time correctly pronounced. This exercise was exceedingly slow—it required eighteen minutes, ten seconds, and while the lesson was retained for one day, on the next it had been forgotten, and twenty was again twentwŭ.

Our studies of M. P. show that he made active use of visual images of objects as, for example, in his work with the Healy pictorial completion test. His capacity to copy indicated that his visual equipment

was adequate to receive correct impressions of the stimuli and to translate them into one form of motion-copying. He could translate his ideas into speech, and his product here must be considered quite good when allowance is made for the fact that practically his whole vocabulary had been acquired by hearing. He could not, however, translate these same ideas into writing. It is true that with great effort, much expenditure of time and many errors, he could make out many words by reading and could write many correctly, but prompt and facile reading and writing were impossible for him. From his writing to dictation, it is clear that the sounds of dictated words did not arouse accurate visual images of letters, except when he laboriously spelled out each word a letter at a time, and even then many were incorrect. His composition suggests that his ideas were even less effective than were dictated words in bringing up the proper visual associations. Conversely, the printed or written word failed to arouse its corresponding concept or its auditory association, so that silent reading as well as reading aloud was impossible for him. Emphasis should be laid, however, on the point that it was in dealing with visual symbols *only* that this associative difficulty occurred. As our records by the Head tests show, there was no interference with the immediate and correct association of objects with their auditory symbols or of the auditory symbol with the corresponding object. He recognized objects and called them by name promtly and correctly, and also indicated them correctly when the name was called. This analysis would seem to indicate a practically complete failure of association operating electively at the symbolic level between the strictly visual cortices and the great association area, as revealed in his difficulty in reading and, conversely, between the association sphere and the visual areas, as shown by his attempts at writing spontaneously and to dictation.

COMPARISON WITH OTHER CASES

The other fourteen cases of reading difficulty encountered in the clinic were necessarily more hastily reviewed, but from the data obtained from these and a few additional cases seen in the outpatient department and elsewhere, it seems that the tendency to read from right to left leading to confusion of such words as on and no or not and ton and the tendency to reversals leading to difficulty in telling a lower case p from q or b from d is of constant occurrence in these children, and tends to confirm the findings in M. P.'s case.

Some of these subjects were tested with a mirror, and were found to read as readily or even more so when the text was seen in mirror image than when seen direct. The motor facility with each hand both in ordinary writing and in mirror writing was also tested briefly in several

cases, and some were found who could write practically as well with one hand as with the other. Others showed varying degrees of success in producing mirror writing. Two wrote their names not only in mirrored reversion but upside down as well, and one boy was found who could read at least as easily, if not more so, when the text was upside down and also seen in a mirror. One child, Clarke C., aged 10, with an intelligence quotient of 102, made four mistakes in simple words (white, bend, nod, dance) in reading from the printed text directly, but he read the whole sentence of fifteen words promptly and correctly when seen in the mirror. This boy had found the second grade in school very hard, was repeating the third grade and was reported by his teachers as "naturally dull." Except in his reading, however, he gave the impression of an alert and interested boy, though very slow and insecure in his motor reactions. His own description of his difficulty is worth quoting. "Hardest one (study) is reading. Arithmetic has always been my easiest study. Mother says there is something funny about me because you could read anything to me and I'd git it

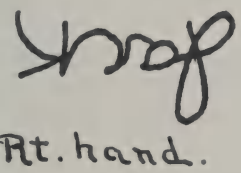


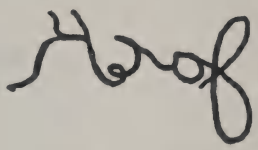
Fig. 5.

right away, but if I read it myself I couldn't git it." This aptly characterizes the group. Another, John C., aged 17, with an intelligence quotient of 72, showed a striking insecurity in telling lower case p from q and b from d. These letters were mixed both when seen directly and in the mirror, and there was no consistency in his mistakes —in one word b would be correctly read, while in the next it would be read as d. John formerly stuttered badly, and still shows traces of this difficulty. He throws and writes with his right hand, but handles a shovel and pitchfork as a left-handed person would. His father is left-handed in everything but writing. Jack D., a 16 year old boy in the ninth grade, gave a Stanford-Binet intelligence quotient of 85, which probably does not represent his full capacity, as he has always suffered from a marked reading disability. He showed an additional factor in that b and d were not only confused with each other, but also with p and q as though there were a factor of inversion here as well as a mirrored reversal. When asked to attempt to write his name in mirror writing after having seen a pattern so written by the observer, he wrote it as seen in Figure 5.

His attention was called to the fact that this was upside down, but not a mirror image, and he was asked to try again with his left hand, with the result shown in Figure 6.

As will be seen, the first is inverted, the second reversed.

This inversion in writing occurred in partial form in one other boy, Karl K., aged 9, third grade, intelligence quotient, 99. Copies of his direct writing with his right hand and his attempts at mirror writing



Lft. hand.

Fig. 6.

are shown in Figure 7. In the attempts at mirror writing, he has produced with each hand a mirrored form of Ka, but has merely inverted the rl.

Karl also apparently had difficulty in both vertical and lateral orientations in reading, as shown by the fact that lower case p was often confused with b and d, although q was consistently recognized correctly.

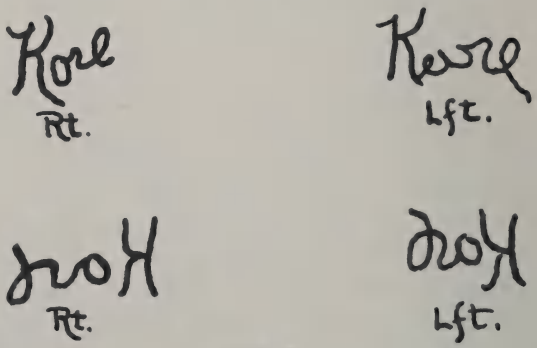


Fig. 7.

M. R., aged 30, intelligence quotient, 93, came to the outpatient department of the hospital for vocational advice. She had always had difficulty in spelling and in learning things by reading, although she had managed to graduate from college by dint of hard work and possibly some favoring by her teachers because of brighter brothers and sisters who had preceded her. She gave interesting evidence on brief study of the tendency to reversal of direction in reading. She had never attempted to read with a mirror, but on the first trial she read the first

five simple words of a printed sentence, the sixth word was "round," and as this was not immediately recognized, she started to spell it audibly as b-n and then stopped as though puzzled. Apparently as long as the words were short and easily read as a whole there was no difficulty with the mirrored images, but when one was met that did not immediately arouse its proper auditory association, she reversed it and began to try to puzzle it out by spelling it backward, suggesting a return to an earlier habit of approach to difficult words.

One of the most convincing observations came from a case, M. O., which was not one of the clinic series. This was a little girl who on her first attempts at writing produced a definite mirrored reversal of each letter with her right hand. It seems axiomatic that the visual image of the letter that was called up by its name, and which must have served as the motor pattern, existed in her brain as the mirrored reversal of that which we consider the correct form of that letter.

Certain additional facts of interest, related to the general problem of cerebral dominance, came out in this group. Many of these children are clumsy with both hands, or had been so in earlier childhood. They are often of the "motor incoordinate" type with evidences of mild apraxia. Some of them give a history of delay in learning to talk and walk and of lack of nicety of balance and consequent frequent falls and of indecision in the choice of the right or left hand in using the knife. fork and spoon, all of which speak for a definite delay in decisive dominant control of the motor mechanisms. Again, several authors have called attention to the frequent occurrence of stuttering in left-handed children and in those with no established lead, when learning to write with the right hand, and, in some, of the rapid disappearance of this trouble when writing with the left hand is permitted. In our series of fifteen cases of reading disability seen in the Greene County Schools fourteen were boys—a fact of interest in connection with the much greater incidence of stuttering in boys than in girls, and of these fourteen boys there were three who stuttered or who had formerly done so and four others whose speech had a peculiar labored hesitancy quite like that of one who has been broken of stuttering.

LEFT-HANDEDNESS AND MIRROR WRITING IN DEFECTIVE CHILDREN

No attempt has been made in preparing this preliminary report to go into the literature of mirror writing and allied phenomena exhaustively, but a few facts of interest to this study have been encountered. Gordon [4] reports the finding of an extremely large proportion of left-handed children and mirror writers among the pupils of the special

4. Gordon, Hugh: Brain 43:4, 1920.

schools for "defectives" in London and Middlesex. He explains that these schools are not institutions for the feebleminded but are provided for children "who not being imbecile and not being merely dull or backward are defective, that is to say, children who by reason of mental or physical defect are incapable of receiving proper benefit from the instruction in the ordinary public elementary schools but are not incapable by reason of such defect of receiving benefit from instruction in special classes or schools." It will be seen therefore that he was dealing with children of the "ungraded" or "special" class type rather than defectives as we use the term. Gordon's first observation was that there was a much higher percentage of left-handed children in one of these special schools than in the ordinary elementary schools. He then carried out a large series of tests to determine motor predilection for right or left, and found that in schools for the defective the left-handed boys constituted 16.6 per cent., the girls 20.7 per cent., or an average of 18.7 per cent., which he states is more than two and a half times as high as in the ordinary elementary schools. He quotes the proportion of left-handedness in normal persons as found by Ogle as 4.5 per cent., Gould 6 per cent., Jones 4 per cent., Malgaigne 8 to 10 per cent., Hecht and Langstein 12 per cent. and by Masini as 10 per cent. It will be seen that his findings in the "defective" children are considerably above the highest of these figures. Gordon also studied mirror writing in these children, and found that 8 per cent. of a total of 1,350 were mirror writers. The product was very good in 56 per cent. of these; good in 29 per cent.; fair in 7.5 per cent. and bad in 7.5 per cent. Fifty-seven per cent. started to write at the right margin of the paper, 13 per cent. in the middle and 30 per cent. at the left margin. He quotes an interesting remark by the head teacher of one of these schools, who stated that he had frequently noticed a great improvement in a child's intelligence and school work, with a natural change of left to right hand. Gordon offers the hypothesis that something has occurred which has interfered with the proper functioning of the dominant hemisphere.

Fildes [5] has made an extended study of mirror writing. She reports that mirror writing is common among young children and among defective children and varies from an occasional reversal of single letters to complete reversal of all letters and words (true mirror writing), which is comparatively rare. It is found most frequently among the left-handed, but also occurs among right-handed children who have never written except with the right hand. She carried out an extended series of experiments with mirror writers as a result of which she suggests that the main cause for continued error among the defectives is their tendency to repeat a mistake once made in spite of correction. She

5. Fildes, Lucy G.: Brit. J. Psychol. **14**:24, 1923.

does not, however, offer any hypothesis to explain this tendency, and apparently has not considered the possibility of a mirrored sensory image as the source of this persistence. As a further cause, she hypothecates poor initial observation. That this factor may play some part seems obvious, but that it should be a major factor, is out of harmony with the active use of visual images of objects which many of these children show. M. P.'s score, for example, in the Healy pictorial completion test indicates a high degree of keen visual observation. In conclusion, Fildes reports that a tendency to reversal existed in greater or less degree in all subjects tested, both normal and defective, and may therefore be regarded as a common one.

That mirror writing with the left hand is the normal sinistral expression has frequently been recognized. Javal [6] emphasizes that the complete reversal of direction and orientation of letters is the normal writing for the left-handed and advises that if a patient with a right-sided paralysis or cramp wishes to acquire left-hand writing as rapidly as possible, he should write in mirror fashion. He cites the mirror writing in the manuscripts of Leonardo da Vinci. An interesting account of da Vinci with reproductions in fac-simile of some of his mirror writings was published by Caetani [7] in the *Scientific Monthly*.

Prof. B. L. Ullmann of the State University of Iowa, in a personal communication, has called my attention to some suggestive facts from old Phoenecian, Greek and Latin inscriptions. The Phoenecian writing, like the Hebrew, ran from right to left and the letter K—kaph—in their inscriptions is reversed and appears as ꓘ. When taken into the Greek, however, which was written from left to right, it became kappa and took the direction of our own K. An exactly parallel situation is found in the contrast between the Umbrian and Oscan Italic dialects which followed a sinistrad direction, and in which the K, S, E and other unsymmetrical letters are written in the sinistral form and the Latin which was a dextrad writing and used a letter orientation like our own. In many of the earliest inscriptions there was apparently great elasticity in orientation so that in some the same letter, such as an E for example, appears in both directions in the same inscription. Still more striking is the very old method of writing one line toward the right and then reversing and writing the next toward the left. This gave rise to a back and forth order across the page which was likened to the path of an ox in ploughing a field and hence has been described under the name of bustrophedon or ox turns. The "Old Forum Inscription," of which Huelson [8] says, "Among all the inscriptions

6. Javal: Physiology de la Lecture et l'Ecriture, Paris, 1906.

7. Caetani, Don Gelasio: The Scientific Monthly **15**:5, 1924.

8. Huelson, Charles: The Roman Forum, English trans. by J. B. Carter, New York, G. E. Stechert & Company, 1909.

(Latin) preserved on stone, it is certainly the oldest and is not later than the fifth century, B. C.," was a vertical bustrophedon in which the writing on the stone as erected goes from the top down on one line and from the bottom up on the next. The letters, however, are placed as though on a horizontal base line. Figure 8 is a tracing of Huelson's photographic illustration of this inscription on the four faces of the stone, shown in the horizontal position in order to be more easily legible.

As a whole, there is fair concurrence between the orientation of the letters and the direction of the line. The E, for example, faces con-

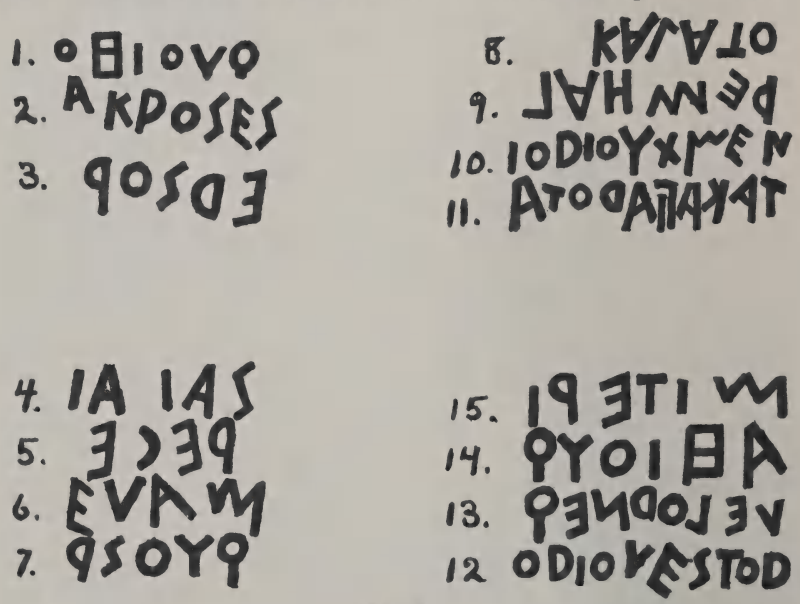


Fig. 8.

sistently in the direction of writing. With the A there is somewhat less certainty. In line 11, for example, the diagonal cross stroke appears in two different letters slanting up with the direction of travel and in two others slanting down. The S, however, has apparently become fixed in one orientation throughout the inscription. Lines 2, 4 and 12 are running to the right, and lines 3 and 7 to the left, but the S in all has the same form. Another interesting feature is shown by the complete inversion of lines 8 and 9, and from Huelson's numbering of 12 to 15 one would infer that these were also inverted with respect to the remainder. Professor Ullman further tells me that he has frequently encountered reversals of letter pairs in medieval manuscripts written by one scribe which are consistent enough to be considered characteristic of that individual writer.

Apparently, at one stage in the development of writing the orientation of individual letters was not of great importance, which probably means that the symbol could be read in either direction. The bustrophedon shows that at another stage both orientations were in use in recording and would imply that both left and right hand forms of letters assembled in corresponding order could be read by educated persons. The growing fixation of dextral orientation of unsymmetrical letters in dextrad writing as the languages developed would indicate that orientation of letters and direction of writing are intimately connected, but the bustrophedon would indicate that exclusively dextrad orientation is by no means determined by brain capacities, but has been established as a purely arbitrary limitation fixed by custom and education.

Sereni [9] calls attention to the fact that mirror writing with the left hand is an expression of the symmetry of build of the body. This is obvious when we consider that, so far as the motor mechanisms are concerned, any innervation of the muscles of the left hand will give a motion exactly opposite to that resulting from the comparable innervation applied on the right. Figure 9 shows these relations in graphic form. This again, however, does not take into account the sensory images which serve as the pattern for writing from memory. Writing in either the direct or mirrored form is possible to some people with either hand, and this potentiality is probably latent in us all though difficult to develop because of the exclusive training of one hand for writing. Sereni [9] reported the case of a man, aged 45, who, two years before, had suffered from a trauma to his right elbow, with a temporary loss of the use of his right hand. He learned to write in ordinary form with his left hand, but later he found that he could write in either the direct or mirrored form with either hand. The dextrad writing produced with the left hand was different from that produced with the right, but the mirrored left was like the dextrad right in its strokes, and vice versa. Sereni considers mirror writing as the carrying over, to one side, of a motor process acquired by the other.

Fildes and Myers [10] have reported a study of a 6 year old boy with a striking tendency toward mirrored reversal of letters and insecurity in recognizing the correct right-left orientation of many of them. He had several left-handed relatives. He had just begun to be taught to write with his right hand, but found difficulty with it, and began to stutter at the same time. He was allowed to write with his left hand, and the confusions of orientation and the disturbance of speech rapidly diminished. Fildes and Myers conclude that the child's early visual experience is probably little concerned with the absolute position of seen

9. Sereni, Enrico: Rev. di psicolo **19**:135, 1923.
10. Fildes, L. G., and Myers, C. S.: Brit. J. Psychol. **12**:3, 1921.

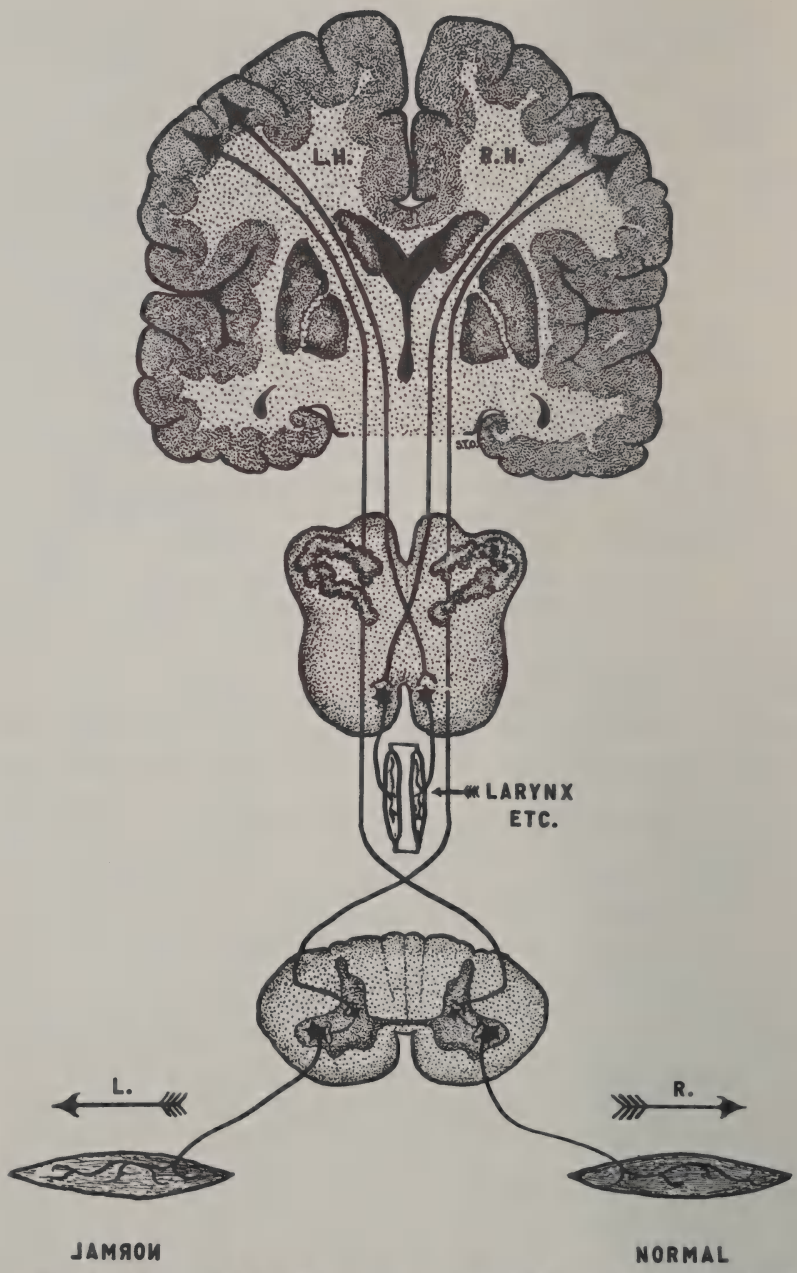


Fig. 9.—Motion of left side exactly opposite that of right in response to innervation of muscles.

objects. His attention is first drawn to form, and his powers of recognition are not gravely disturbed whether that form once learned be represented in the ordinary or reversed or inverted position.

Parson [11] has recently published a book on left-handedness in which he emphasizes the fact that ocular dominance, i.e., the eye used in fixation, corresponds in all except abnormal cases to the "handedness" of the individual. His study is based on the results of experiments with the manuscope, an appartus—sadly misnamed—to determine which is the dominant or sighting eye. Parson apparently holds that the ocular dominance determines both cerebral dominance and the "handedness" of the individual. His figures are striking in indicating that the facile hand corresponds in side to the eye used in fixation. The selection of one eye as the sighting eye might, however, readily be regarded as a result of the establishment of dominance in one brain hemisphere from other reasons rather than determining it. Parson's manuscope was not available to us until after our observations were complete, and therefore no tests of his method of determining the dominant hemisphere were made on our material.

"CONGENITAL WORD-BLINDNESS"

In the medical literature we find the first record of a case of congenital word-blindness made by Morgan,[12] who reported his observations on a child who could not learn to read, although his vision was normal. He was not mentally defective, and he knew the letters of the alphabet, and Morgan gave to this condition the name of congenital word-blindness because of the similarity in many respects to Kussmaul's [13] acquired word-blindness. Hinshelwood [2] published a monograph on the subject in 1917, in which he reported several other cases and discussed them at length in comparison with the acquired condition. Hinshelwood makes a sharp and, I think, unwarranted distinction between mild and severe grades of difficulty in learning to read. He says: "The term congenital word-blindness ought to be reserved for those grave cases of defect where the difficulty in learning to read was so great and so unusual that it could be regarded without any exaggeration as an abnormal and pathological condition and where the attempts to teach the child to read by the ordinary methods had completely failed." He also says: "The rapidity and ease with which children learn to read by sight vary a great deal. No doubt it is a comparatively common thing to find some who lag considerably behind their fellows, because of their slow-

11. Parson, Beaufort Sims: Lefthandedness, New York, The Macmillan Company, 1924.

12. Morgan, W. Pringle, quoted by Hinshelwood, Footnote 2.

13. Kussmaul: Ziemmsens Encyclopaedia der Speciellen Pathologie and Therapie, Leipzig, F. C. W. Vogel, 1881.

ness and difficulty in acquiring their visual word memories but I regard these slight defects as only physiological variations and not to be regarded as pathological conditions." His envisagement of the etiology of true word-blindness as here described is that of a defective development, in the early stages of embryonic growth, of the special cerebral area subserving visual memory of words and letters.

Our own studies would lead us to believe that while there may be additional factors in certain cases which serve to determine a greater severity of the disability in a given child, these cases as a whole form a graded series, and it is only the occasional child in whom a fair facility in reading is not ultimately achieved and who would therefore fit in Hinshelwood's group. At the present stage of our study, the factor of reversals of individual letters and the tendency to sinistrad reading of letter groups or whole words seems to characterize all of these cases. How many may show a second factor like that exhibited by M. P. in his faulty range of sound associations with the vowels or like the inversions suggested in Jack D.'s case can be determined only by further study. Hinshelwood's conception of a defective development of the cortex destined to become the center of storage for visual word memories is also out of harmony with the more modern conceptions of cortex function. Marie [14] calls attention to the fact that an infant with right hemiplegia never presents aphasia, and he believes that the temporal region, the gyrus angularis and the surrounding zone are not in any sense preformed centers for language, but brain structures adapted by training to that function. Apert,[15] reporting on a case of congenital familial dyslexia, calls attention to the fact that this, like congenital aphasia, is an entirely isolated disability—that is, it is not a part of a general mental defect—and that later the development, which has been checked, recurs. He also has emphasized the fact that children with right hemiplegia are not aphasic, and he expresses the opinion that these developmental delays (hemmungen) are not of anatomic but of functional origin. Pick [16] lists together mutism, infantile agrammatisms, congenital word-blindness and difficulty in the auditory memory as the underlying conditions resulting in check in development of expressive speech in children. Pick also emphasizes that these are not accompanied by a defect in general intelligence, and that after some time normal development proceeds. He states emphatically that these cases are of the group of developmental delays and are not to be considered as defects due to brain lesions.

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14. Marie, Pierre: Presse méd. **17**, March 1, 1922.
15. Apert, E.: Bull. méd., Paris, **38**:9, 1924.
16. Pick, A.: Med. Klin. **20**:21, 1924.

The evidence available from histologic studies demonstrates that there are three distinct types of visual cortical mechanisms, and the data gathered through correlation of clinical studies with the necropsy findings in cases of focal brain disease indicate that there are three corresponding functional levels. Figure 10 shows the distribution of these three different histologic types of cortex on the mesial and lateral aspects of both hemispheres of the brain.

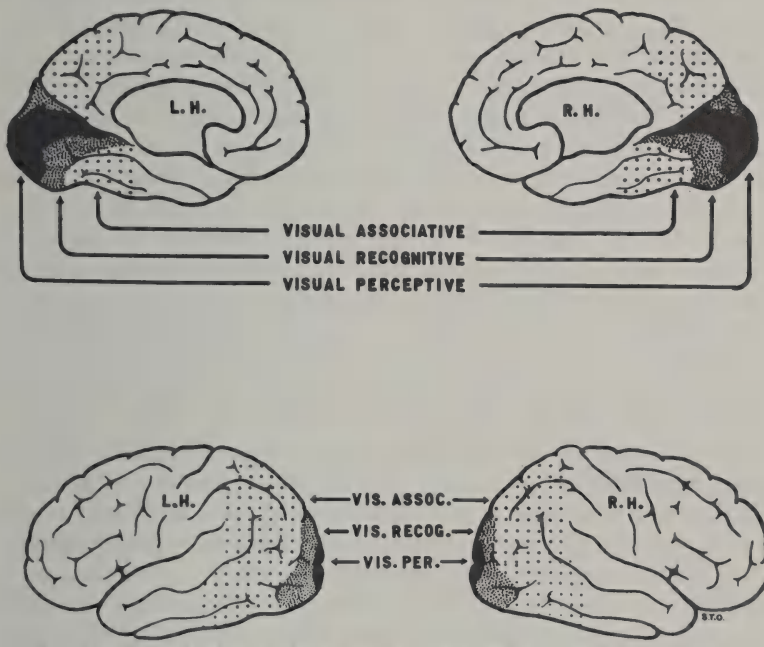

Fig. 10.—Distribution of three types of cortex in hemispheres of brain.

The first of these levels is indicated in the illustration by solid black and by the name "visual perceptive." This is the arrival platform, calcarine cortex or area striata. This last name was given because of the presence of a heavy white band of nerve fibers about midway in the depth of the cortex, which sharply demarcates this field and makes it possible to recognize its exact limits with the naked eye. When bilateral destruction of this cortex occurs, there follows complete blindness. The lower reflex centers are still operative, but no visual impressions of any kind enter consciousness or serve as a control of volitional motor responses. These results do not follow unilateral destruction in this field. This cortex was called the visuosensory by Campbell.[17] The

17. Campbell, A. W.: The Localization of Cerebral Function, Cambridge, University Press, 1905.

term "sensory," however, embracing as it does the whole receptive and recording mechanism, seems too wide for this restricted functional zone, and I have for some time used the term "visual-perceptive" here. This usage will be explained in the discussion of the next level.

The second level is marked in Figure 10 as the visual recognitive and shown by the area of stippling. This is the common occipital type of cortex which practically surrounds the arrival platform. The distribution given conforms to that of Campbell's map and quite closely to Brodmann's [18] area occipitalis, field 18. With extensive losses of this cortex there is retention of mere awareness of visual stimuli but loss of recognition of their meaning. This is the condition known as mind-blindness, which can perhaps best be illustrated by the results of Munk's experiments on dogs, in which it was first recognized and described. After wide ablation of the occipital lobes, Munk found that his dogs were still able to get about without collision with objects—that is, the animal still retained sufficient control of the motor acts by visual stimuli to guide its movements, but it apparently failed to gain the meaning usually carried by such stimuli. Threats with a whip, sight of food when hungry or the sight of its master, except when reinforced by additional sensory data from other fields, evoked no responses. Clinical states of similar type in man have since been recorded in numbers, and from anatomic studies of these, it is obvious that they arise from extensive *bilateral* destruction of the occipital cortices, but only when there is retention of part at least of the visual arrival platform or calcarine cortex. When destruction is unilateral, this complete loss of the capacity to recognize objects does not follow. This separation of awareness of a stimulus from recognition of its meaning is not so completely accepted by the psychologists, who include both of these functions in the term "percept" because of the difficulty of separating them by introspection. The evidence from pathology and histology is so clear-cut, however, that I have come to separate these functions and to restrict the use of the term "perceptive" to that of the first level, i. e., awareness without meaning, and I have so marked the arrival platform on the plate. The second area was called the visuopsychic by Campbell, but the term seems indefensible, and I have used the descriptive term "visual recognitive" for this level.

The third level—the visual associative—is not to be considered a unitary sensory platform in the sense that it is specifically visual in function, as it is in this great posterior association zone that associative interlinking of the data garnered in various sensory fields probably occurs. This field is indicated in Figure 10 by spaced dots, but the area

18. Brodmann: Vergleichende Localizationslehre, Leipzig, Johann Ambrosius Barth, 1909.

so demarcated is not intended to show its exact extent or boundaries, but merely to indicate that those cortices of the association zone which lie nearest the visual recognitive field probably play a preponderantly visual part in the associative function. This area as outlined includes part of Campbell's common temporal and parietal areas, and includes Brodmann's area prae-occipitalis, field 19, area occipito-temporalis, field 37, area angularis, field 39, and part of his area parietalis superior, field 7. There is no such clear mark of identification of the recognitive and associative cortices as we find in the white line of the arrival platform, and microscopic analysis of the architectonic patterns is therefore necessary to determine their extent. Lesions of the third level result in the condition known as word-blindness, in which awareness of objectivity and recognition of the concrete meaning of objects are both retained, but in which the abstract or associative meaning of the printed word is lost. Here, however, for the first time, we see a sharp difference between the results of lesions in the two hemispheres. In both the lower platforms, extensive bilateral lesions are apparently necessary to destroy the respective functions. In the third level, a unilateral lesion is sufficient but only when it occurs in the dominant or lead hemisphere—the left hemisphere in right-handed persons, and vice versa.

To these three separate levels of the visual function, I think that we may tentatively apply the physiologic hypothesis that each related irradiation from one cortical zone to the next must be simultaneous or immediately successive in time, and must be concordant in detail to permit associative linkage. A sensory stimulus which reaches the two arrival platforms results in one conscious impression which we call awareness or the sense of objectivity. We may assume that if the overflow of these impulses into the two recognitive cortices be harmonious in both time and form, the external stimulus will have that correspondence with its respective memory image which constitutes recognition of its meaning. The combined irradiation of the first and second platforms would then result in both awareness of objects and the recognition of their meaning. Activity in the second level aroused by association but without the participation of the first would result in a visual memory, but without the sense of objectivity which characterizes the combined action of both platforms and which serves to differentiate for us the memory image from sensory experience. In the formation of a concept or associative memory, we would postulate the simultaneous or immediately successive irradiation of concordant stimuli into at least three platforms. The arrival platform or visual perceptive would give awareness, the overflow into the recognitive would add concrete meaning of the object or symbol and into the associative would add abstract or symbolic meaning through interlinking with sensory data from other fields.

From the fact that loss of the capacity to read follows a unilateral lesion only when this occurs in the dominant hemisphere may we assume that irradiation is necessary into only one of the two third level cortices to produce a linkage between visually presented symbols and their meaning. That one or the other hemisphere or one locus in one hemisphere must have an initiatory function for all volitional motor responses seems obvious. Were it not for this placing of the lead or control in one side, the two hemispheres might originate opposed or conflicting responses to a given situation. In man's brain the entire initiatory control of certain major functions, such as speech, writing and reading. seems to be in one hemisphere, as is illustrated by the occurrence of the alpha-privitive symptoms—aphasia, agraphia, alexia, etc., following unilateral lesions. Dominance of this degree has not, I believe, been demonstrated in the lower animals, but some form of initiatory control would seem necessary to prevent confusion of responses such as would result if either hemisphere were competent to lead without reference to the activities of the other.

With the recognition of the dominant part played by the associative cortices of the left hemisphere in right-handed persons, attention was drawn from the function of these areas in the right hemisphere. In every study of the subject of volitional speech, writing, etc., the functions of the various areas in the left hemisphere are discussed in detail, as indicated by clinical correlations, but I do not at present recall ever having seen any attempt to envisage the physiologic conditions existing in the corresponding areas of the opposite hemisphere. Many of these cortical fields in the right hemisphere are listed among the "silent areas," and apparently the fact that they are probably activated by incoming stimuli has been entirely overlooked, because attention has been directed to the left hemisphere on account of its dominance and the striking results of interference with this dominance by unilateral lesions. When we consider the visual cortices in the light of their anatomic structure, we must remember that here are structures of almost if not quite equal size, extent and neuron content. In fact, about the only structural difference is that one is the right-left counterpart of the other. I have at my immediate disposal no exact data on the relative weight of the two hemispheres of the human brain, but some years ago, a considerable series of such weights was recorded in the Worcester State Hospital in Massachusetts, and, as I remember these findings, there was rarely a difference of more than 20 to 30 gm. in the size of the two hemispheres, and in several instances this discrepancy was in favor of the right hemisphere from patients who were right-handed, at least so far as writing and the common motor acts were concerned. For many years, as a routine measure, I have cut pieces of cortex from six comparable areas of both the right and left hemispheres, one set as squares and the

other as triangles. These blocks have then been embedded in pairs and cut together so that the slide representing the occipital cortex, for example, in a given case will show a square and triangle, from the right and left hemispheres respectively, mounted side by side. Certain cases, of course, such as paresis and the vascular obliterations, will show marked differences in the two sides, and I have never carried through any accurate studies of the number and development of cells in each hemisphere; but the general impression, gained from the study of several thousand such paired sections, is one of comparative equality. If we follow Kapper's theory of neurobiotaxis, we must consider that the cells of the right hemisphere would not have reached this stage of comparatively full development without constant activity, and that their development is the result of irradiation which takes place equally into all parts of both hemispheres; we must further assume that this irradiation into visual areas of the associative cortex of the right (or non-dominant) hemisphere forms a mnemonic record there.

The exact symmetrical relationship of the two hemispheres would lead us to believe that the groups of cells irradiated by any visual stimulus in the right hemisphere are the exact mirrored counterpart of those in the left. That simultaneous activity in these antitropic nerve cell groups may still give us a single conscious sensation, is shown by Sherrington's [19] study of sensory fusion. He studied visual fusion by means of a special apparatus and came to the conclusion that "during binocular regard of an objective image each monocular mechanism develops independently a sensual image of considerable completeness. The singleness of binocular perception results from union of these elaborated sensations." Cases of amblyopia show us that this fusion occurs only when the images strike retinal areas which correspond through associative training, but when the squint remains a new correspondence is ultimately acquired, suggesting that the fusion of the two images into one conscious impression is a function of education rather than of neuron pattern.

I feel that our evidence as to whether the fusion of the results of stimulation of oppositely oriented nerve cell clusters into a unitary sensation is a function of the arrival platform alone or also obtains in the recognitive zone is not quite precise. However, loss of the ability to recognize the meaning of objects (mind-blindness) occurs only when there are bilateral lesions of the recognitive zone, which suggests that fusion does occur at this level.

The fact that unilateral lesions in the visual associative cortices result in loss of symbolic meaning (word-blindness, etc.) would lead to the conlusion that the mnemonic record contained in the right hemisphere

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19. Sherrington, C. S.: The Integrative Action of the Nervous System, New Haven, Yale Univ. Press, 1906.

is not requisite for the formation of a symbolic association, and that at this level fusion between right and left mnemonic records does not occur. The tendency common in young children to mirrored or reversed writing, as reported by Fildes, and as seen in our own cases, and the spontaneous production of a mirrored reversal of letters on first attempts at writing with the *right* hand, as recorded in the case of M. O., all point to the existence in the brain of a mnemonic record in mirrored form which serves as the pattern for these motor expressions. Further, the difficulty in our cases of reading disability in differentiating p from q and b from d and their tendency to confuse palindromic words like not and ton and on and no suggest that the mnemonic record exists in the brain in both orientations.

Letters are in themselves merely objects until they have come to acquire meaning through sound associations or through association in groups of sounds which constitute a word. We would therefore assume that in the process of early visual education, the storage of memory images of letters and words occurs in both hemispheres, and that with the first efforts at learning to read the external visual stimuli irradiate equally into the associative cortices of both hemispheres, and are there recorded in both dextrad and sinistrad orientation. Images of objects require no definite orientation for recognition or differentiation, but when we are dealing with letters, which have come by custom to be used in one orientation only, it is clear that the orientation of the recalled image must correspond with that of the presented symbol, or confusion will result.

This suggests the hypothesis that the process of learning to read entails the elision from the focus of attention of the confusing memory images of the nondominant hemisphere which are in reversed form and order, and the selection of those which are correctly oriented and in correct sequence.

Figure 11 gives a graphic outline of this conception. The symbols indicate the fusion into one sensation which occurs in the perceptive cortical platform and probably also in the recognitive platform. As the associative level, the dominant images are given in bold face and the elided ones in outline. The cortical fields are indicated as in Figure 8, except that the arrival platform is marked by the line of Gennari instead of by the solid black.

The frequency, in these cases of reading disability, of reversals of letter pairs, such as we see in M. P.'s gary for gray, of whole syllables, as tar-shin for tar-nish, or of the major parts of words, as tworrom for tomorrow, strongly suggests that there has been an incomplete elision of the memory patterns in the nondominant hemisphere, and that therefore either right or left sequence may be followed in attempting to compare presented stimuli with the memory images, and that this leads

to confusion or to delay in selection. It seems obvious that such confusion would result in a distortion of the motor output in both speech and writing, and if we assume that the additive function of further associative interlinking with auditory and other sensory images must also be simultaneous or immediately successive, we can readily envisage how delay in selection might interfere with the linking of presented visual

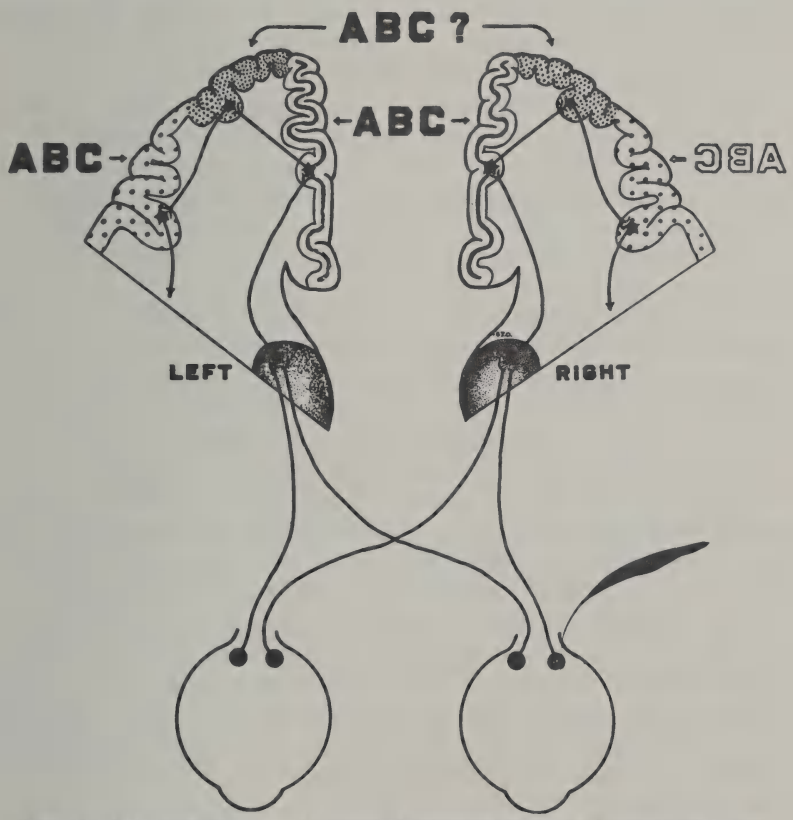

Fig. 11.—Selection of correctly oriented memory images in focus of attention.

symbols with the auditory component of its concept, and hence result in a failure to recognize the meaning, i. e., to read the word as a whole. Most of these children learn to recognize correctly the individual letters, and can also read by name and in proper sequence each letter of those forming a printed word or, as in M. P.'s case, can follow the proper sequence in copying. Here the sequence is determined for them by the external stimulus. When, because of failure in training for automatic elision of the obverse record, however, the mnemonic images may be

recalled in either sequence, they may fail to correspond with the external stimulus, and delay or confusion will follow and may result, as above suggested, in failure of proper association. That training for elision of one set of images may operate in either hemisphere is obvious when we consider that dominantly left-handed children have apparently no greater difficulty in learning to read than do the dominantly right-handed. Those children, however, who are neither dominantly right-handed nor left-handed, or in whom clear dominance has not been well established before they begin to learn to read, probably have more trouble with reversals of letters. The factor of educational method probably also plays a large part here, which will be discussed briefly later. Whether other factors enter into the more severe grades of this disability and hence determine a greater permanence of the condition in certain cases, cannot be determined without much wider observation and experiment. Such enlargement of the study is projected for the immediate future.

The term "congenital word-blindness" because of its association with the acquired condition and the implications therefrom, does not seem to be properly descriptive of this disability, and I would therefore like to offer the term "strephosymbolia" from the Greek words, *στρέφω*, twist, and *σύμβολον*, symbol, as a descriptive name for the whole group of children who show unusual difficulty in learning to read. The prefix "strepho" has been chosen to indicate the turning or reversals as it does in the word "bustrophedon," as illustrated above. "Symbolon" is used in its original meaning of "word," "sign" or "token," and not as in Finkelnburg's usage in "asymbolia," in which it included recognition of the meaning of objects as well as of symbols, nor as in the very restricted sense of Oppenheim as a synonym for apraxia. Strephosymbolia thus seems nicely suited to our cases in which our analysis points to confusion, because of reversals, in the memory images of symbols resulting in a failure of association between the visually presented stimulus and its concept.

ERRONEOUS ESTIMATE OF INTELLIGENCE OF DEFECTIVE CHILDREN GIVEN BY PSYCHOMETRIC TESTS

Brief observations on the cases of this reading disability so far studied have brought out several points of psychiatric interest.

It has been pointed out by numerous writers, some of whom have already been quoted in this report, that this difficulty, as is also true of many of the speech and auditory disturbances, is an isolated disability, is not the result of a general mental defect and, further, that often it corrects itself. Nevertheless, there is a strong tendency to characterize these children as "defectives." This has, of course, been furthered by the belief of Hinshelwood and others that there is here a true focal

lack of development in the brain center for visual word memories. Because the term "defective" so constantly implies a general intelligence defect, I have consistently attempted to make use of the word "disability" in describing this difficulty. That the reading disability does not correlate with a low intelligence quotient is obvious from the psychometric ratings of our fifteen cases which show the following distribution:

TABLE 6.—*Psychometric Ratings in Author's Fifteen Cases*

Group	Stanford-Binet Intelligence Quotient	Cases
Superior intelligence	122	1
Average intelligence	91 to 105	9
Dull normal intelligence	85	1
Marginal defective	70 to 75	4

It can be seen by reference to Table 1, that with only one exception all of the children of the lower grades were in the average normal intelligence group or higher but that the four in the higher grades were in the marginal defective or dull normal groups. It might, of course, be inferred from this that only those of inferior equipment failed to overcome their handicap and ultimately to learn to read. I feel, however, from our work with M. P. that this is a distinct problem which will require additional investigation. M. P. had by far the most outstanding case of the series, and I have been far from content, after close personal study, that either the original rating of 71 or the revised rating of 86 really estimated his general intellectual capacity. I think we must therefore challenge the competence of the Stanford-Binet method to give us even an approximate rating in these cases. These children fall in a group of an especial nature more closely comparable to those with true sensory deprivations than to the so-called feebleminded, and there are apparently three factors here which must be considered in judging the adequacy of the test: First, the ratings given are the result of the application of the test to large numbers of children of each chronologic age. In any such group, unless selected on the basis of a reading difficulty, the number of such cases would naturally be small, and we are therefore comparing these handicapped children with an unlike standard. Second, the material of the test itself consists in part of words which are visually presented, and this penalizes their handicap heavily. This factor was an operative one in the change of intelligence quotient in M. P.'s case from 71 on the first examination to 86 on the second. It would seem that a modification of the method might readily be devised to use only auditory presentation except for those parts of the test that deal with images of objects, such as the ball-in-field test, etc., and that this might readily give a better estimate

of their equipment. Third, one path of acquisition of information open to the average child, that of reading, is more or less completely closed to these children. When we realize that M. P.'s disability was so great that practically none of his verbal store had been acquired by vision, we appreciate that his accomplishments in the test are far from establishing as low a capacity as the rating would indicate. This lack of information, however, is not a competent measure of how effectively he can make use of those data which he has garnered by the auditory path.

Several psychiatric reaction patterns were observed in various cases of our series, some of which seem to have a fairly direct derivation from the disability and might readily serve to establish determining character traits.

The first of these was a contented, apathetic disregard of the handicap and its results. M. P. showed this reaction. He was at all times cooperative and entered willingly into all the tests and training experiments, but at no time did he show even a trace of spontaneous interest in his condition or of ambition to overcome his disability. He had apparently made a complete adjustment to his situation and was content to accept himself, as others rated him, as different from other boys; but he had apparently developed no particular feeling of inferiority, nor had he suffered from any emotional blocking because of this difference.

The second type was seen only in outline, and no older cases of similar reaction have yet been encountered. This was a mild paranoid reaction toward the teachers on the part of one or two children who felt that they were being asked to do something that was impossible—as it was for them—when they were expected to keep pace with others in their classes in reading.

The third pattern was brought out with extreme clearness in an adult—M. R., aged 30, whose case is briefly quoted above. She not only had a comparatively severe grade of the disability, but was also of that mild motor incoordinate type in whom many exact motor acts are acquired slowly and with difficulty. She had grown up in a family of brothers and sisters who were probably above average in intelligence and dexterity, so that she had been constantly impressed both at home and in school with the feeling that she was of not quite the same status as the others of her family. The result of this atmosphere was the development in M. R. of an overpowering sense of inferiority which served as an insuperable obstacle to her own efforts. On first examination, she appeared entirely colorless from the emotional standpoint, and was apparently completely submerged by her feeling of inferiority. When, however, her striking reading disability was uncovered, and it was explained to her that this did not necessarily imply a general defect of intelligence, she brightened somewhat, and when she

was asked whether she, herself, felt that she was as incompetent as her family had led her to believe she replied, *"I do not!"* with the first real emotional response elicited.

The fourth type of reaction was observed in varying degree in several children. This was an emotional blocking. M. O. gave the best illustration of this. After she had been in school for some time—making indifferent progress—her mother observed that she was failing in school on work which she knew and made practical use of at home. The mother asked her specific questions on this sort of material on her return from school one day and received the reply, "I don't know," which had become almost a stereotyped reply to all questions on school knowledge. A few moments later M. O. volunteered the exact information for which she had been asked, and when her mother inquired as to why she had not responded before, she replied, "I can tell you, if you will let me tell it myself, but when you ask me I can't tell you anything." This child has since been taught to read with fair readiness for her age, but the blocking of output when anything is demanded as a task or assignment is still very much in evidence in all her efforts.

OVERCOMING OF DISABILITIES BY SPECIAL TRAINING

Little opportunity has as yet been found to review in detail the literature of the teaching of reading, but the hypothesis herein developed concerning these special disabilities would seem to bear heavily on the subject of reading as a whole as well as on these particular cases. Harman [20] accepts the brain defect hypothesis, and calls attention to the fact that practically all of these children learn the ten arabic numerals and most of them learn the twenty-six letters of the alphabet but do not learn to recognize words as a whole, and he feels that this gives the clue to the method for training. He says:

> They must be taught on the plan of the Chinese. . . . A certain mark (Chinese character) conveys to the taught child the idea of a house just as does a picture or as the symbol 1 does the idea of unity or one. To teach these children reading we must fall back on this plan. The word cat must be taken as a whole, not as c-a-t =, but the whole thing is the sign for cat. This method is known as the "look and say" plan, and when carried out by a teacher of intelligence and with great patience, it is possible to teach the child to read. In such cases it is obvious that individual teaching is necessary to secure any effective progress.

Apparently Harman overlooked the logical absurdity in this. Reading whole words at a time is a later acquisition than reading letter by letter, and would seem to be the function of that exact cortical area—the visual memory center for *words*—which Hinshelwood postulates as

20. Harman, U. Bishop: Kelynack's Defective Children, New York, William Wood & Company, 1915.

undeveloped, a theory which Harman apparently accepts. Hinshelwood, in discussing Harman's views, states that he is satisfied that in teaching the word-blind to read the old fashioned methods are preferable to the "look and say" method or, as it is known in this country, the "flash" or "sight reading" method.

The tentative envisagement of the disability herein outlined would suggest that the logical training for these children would be that of extremely thorough repetitive drill on the fundamentals of phonic association with letter forms, both visually presented and reproduced in writing, until the correct associations were built up and the permanent elision of the reversed images and reversals in direction was assured. The flash method would seem from this point of view not only to be inadequate to correct early mistakes in orientation, but also to put these children under an unnecessary and unjust handicap, at least until they had acquired the fundamentals in readily available form. The child has no opportunity to puzzle out whether a symbol means p or q by the flash method, and many such initial errors might well be perpetuated. When a child looks at "not" and reads it "ton," the teacher's first reaction is that the child is inattentive or is not trying, and she is apt to apply either discipline or ridicule, which in turn engender an emotional blocking or a feeling of inferiority without, however, correcting the difficulty. These factors are to some extent illustrated in the case of M. O., which has been quoted above in other connections. She started in school in the first grade at 6 in a room in which the "flash" method of teaching reading was used practically exclusively. She spent two years in this grade, and then advanced to the second only after special coaching in the summer vacation period. In this grade she had a more sympathetic teacher, who gave her more encouragement, and her progress was more rapid although her reading was extremely slow and insecure. In the third grade, she fell into the hands of a teacher who expressed the idea that M.'s trouble was because she was not trying hard enough and attempted to stimulate her progress by pressure. During the first few months of this year, M. O.'s emotional blocking became so great that she was definitely losing much that she had had at volitional command during the preceding year. She was withdrawn from school, and her mother was advised to attempt to train her to read by a return to the old fashioned methods of repetitive drill with painstaking correction of mistakes, and after a few months of this training she had practically corrected the whole difficulty. She still has considerable uncertainty, however, in differentiating on and no, of and for and other short words which were fixed in confused order for her during her period of "flash" training. According to our hypothesis, the training should aim at teaching the child to focus the attention on the correct set of images, and for this purpose the repetitive a-b = ab sort of kinder-

garten drill would seem to offer the most promise. The results of this type of training in M. O.'s case are sufficiently encouraging to warrant the extension of experiments along this line.

It would be of great interest to know whether the comparatively high number of cases encountered in our survey result from any particular characteristics of the teaching method in the local schools, and, further, whether a greater proportion of these disabilities are to be observed in those schools using the flash method than is found in those which still adhere to the older drill methods.

In the table giving the distribution of these cases by grades as found in our survey, it is of interest to note that in the first grade there is only one child—here the teaching is of letters chiefly with only a few simple words. In the second and third, however, in which the reading of more difficult words is added, there is a striking increase in number. From here the cases drop sharply except for the four boys in the seventh, eighth and ninth grades. Our series is of course too small for deductions, but this distribution would suggest that the majority of these children make their own adjustment to this difficulty and learn to read without special training. Some, however, do not, and it would seem as if methods could be devised which will teach those with outstanding cases to read, as well as shorten the period of emotional stress in cases of lesser severity. It is obvious, however, that to be effective such methods must be developed in consonance with a sound neurologic background and be adequately controlled by careful observation and experiments in training. This program we expect to extend in the immediate future.

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GENETIC PSYCHOLOGY MONOGRAPHS

Child Behavior, Differential and Genetic Psychology

METHODS FOR DIAGNOSIS AND TREATMENT OF CASES OF READING DISABILITY*[1]

BASED ON THE COMPARISON OF THE READING PERFORMANCE OF ONE HUNDRED AND TWENTY NORMAL AND ONE HUNDRED AND SEVENTY-FIVE RETARDED READERS

From the Iowa State Psychopathic Hospital

By

MARION MONROE
University of Chicago

with a foreword by
SAMUEL T. ORTON, M.D.

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[1]This study forms part of a program of Research in Physiology of the Brain carried out at the Iowa State Psychopathic Hospital in 1926-1927 under a grant from the Division of Studies of the Rockefeller Foundation.

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FOREWORD

From a brief study of fifteen cases of reading disability seen in an experimental mobile mental hygiene clinic held in Greene County,[1] Iowa in January, 1925, and from a somewhat more extended study of one of these cases[2] in the Iowa State Psychopathic Hospital, I was impressed by the possibility that such children might be handicapped by a physiological variation which unfitted them for progress in reading by the methods as at present taught in the schools, but which was not to be looked upon as the result of a general mental defect, nor as a congenital brain defect as hypothecated by Hinshelwood, nor as a defect in the perceptual function, nor as the result of emotional factors, as suggested by others. A possible explanation of this physiological deviation was offered on the basis of our knowledge of cerebral physiology.

The theoretical background of this hypothesis would occupy too much space to give in detail here, but briefly it has to do with the general problem of cerebral dominance and envisages the reading disability as a fault in training the brain to work exclusively from the leading or dominant hemisphere. In the case of the lower visual centers which have to do with perception and the recognition of objective meaning, similar areas of the two hemispheres apparently function together as

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[1]Lyday, J. F. The Greene County mental clinic. *Ment. Hygiene,* 1926, 10, 759-786.

[2]Orton, S. T. "Word blindness" in school children. *Arch. Neur. & Psychiat.,* 1925, 14, 581-615.

a unit, as is shown by the fact that at this level destruction of similar areas on both sides of the brain is necessary to produce loss of function (cortical blindness and mind blindness). At the visual associative level, however, at which the visual element is linked with the sensory data from another field, as for example when a printed word calls up its sound or its meaning, this rule of bilateral function apparently does not apply. Clinical studies have pointed out that the destruction of a small area on one side is sufficient to destroy the visual associative function, but only when the area so destroyed is that of the dominant or leading hemisphere. Such a unilateral destruction leads to the condition of alexia or acquired word blindness in which the patient can see, can read individual letters and figures, but cannot read printed or written words. An exactly similar destruction in the non-dominant hemisphere gives no demonstrable evidence of its existence. This striking difference in functional importance between the right and left association areas is not, however, paralleled by an equivalent difference in brain structure. The association areas in the non-dominant hemisphere are, as far as we know, equal in size and in complexity to those of the dominant, and by inference we must assume that these areas hold records, known as engrams, which are usually latent or elided but which may under certain circumstances influence responses. Since the visual spheres of the two halves of the brain are antitropic (i. e., right and left), we believe that visual engrams are registered there as antitropic pairs and that originally either is

competent to become the guide for motor responses. The establishment of the physiological habit of initiating the more intricate motor responses, such as speech and writing, from the association area of one hemisphere alone usually occurs early in childhood, but apparently at varying ages, and expresses itself outwardly in a preference for the right or left hand, as the case may be. This establishment of unilateral dominance presupposes the elision of the engrams of the other hemisphere at the associative level so that they no longer serve as a pattern for the motor responses of speech and writing.

As a further elaboration of this concept it seems probable that only one of these antitropic engrams serves as the basis for associative linkage between the visual sphere and the concept, and that if a clear cut unilateral dominance be not established by the elision of one of them, confusion might readily arise which would prevent that immediately successive linkage between the sensory stimulus (printed word) and its meaning (concept) which constitutes reading. This envisagement of the reading disability as a lack of establishment of clear cut dominance in one hemisphere was developed from the observed tendency of such children to confuse letters of the same form but facing differently, such as *b* and *d,* and to read from right to left instead of from left to right, and from the facility which some of them showed in mirror reading and mirror writing. These factors seem to be common to the whole group but a variety of other errors were noted in certain individuals. Among the additional

types of errors recorded in my earlier report were errors in vowel sounds, errors in consonants, the addition or omission of letters, substitutions of words, a tendency to perseveration of sounds in a series of words, and frequent repetitions of words. The common errors, that is, those of orientation (*b* and *d*), and of reversal in direction of reading (*was* for *saw*), were considered to indicate the fundamental difficulty, and the other errors were looked upon as a secondary result of the confusion resulting therefrom.

From these observations, I felt that we were in a position to attempt a similar analysis of a larger series of cases to determine whether the association of these reversals with inability to learn to read was really significant. I also suggested that such children probably could be trained to read by repetitive drill on the fundamentals of phonic association with letter forms, both visually presented and reproduced in writing, until the correct associations between the visual and auditory engrams, reinforced by the kinaesthetic, were built up. The kinaesthetic element is theoretically particularly important in correcting the tendency to reversals in direction of reading, and hence was considered of especial value as a retraining method to determine the permanent elision of the confusing engrams.

For the further study of these problems, support was asked from the Division of Studies of the Rockefeller Foundation, and a grant of $30,000 a year for a two-year period was made available to us for a broad attack from varying angles. Work under this gift was begun

in January, 1926. Experimental work was initiated at the Iowa State Psychopathic Hospital in the fields of cerebral anatomy and cerebral physiology, psychological and physiological studies in stutterers were undertaken, and experimental methods were devised aiming to determine the innate cerebral dominance. The Mobile Mental Hygiene Clinic was also organized, which has examined over a thousand school children who presented educational and other problems, in various parts of the state. This field service was intimately linked with the laboratory studies carried on at the Psychopathic Hospital and interchanges of personnel made it possible for both units to keep in close touch with all phases of the work. The field service was largely instrumental in finding the large number of reading disability cases the study of which forms the body of this report.

Miss Marion Monroe was appointed Research Associate in Psychology to undertake the task of putting these earlier findings to a critical test by the impartial and objective analysis of the errors of a larger series of cases of reading disability and to carry forward the suggested experiments in retraining of such children.

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SPECIFIC READING DISABILITY—STREPHOSYMBOLIA

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It has long been recognized that there are certain children who have a more or less selective difficulty in learning to read. The earlier observers of this condition, among them Berkhan,[1] in 1885, apparently assumed that it was related to a general mental defect and described such cases as partial imbeciles (halbidiote). A more or less complete inability to learn to read, particularly when it is associated as it often is with atrocious handwriting and poor spelling, naturally enough would incline the uncritical observer to assume that the child was, if not truly defective, at least not as bright as he should be to accomplish his school tasks. Very often the logic of this explanation forms a typical vicious circle. The child is said to be feebleminded because he cannot learn to read, and his inability to learn to read is said to be because he is feebleminded. Gradually, however, case reports of children who were obviously bright in most respects but who could not learn to read or who progressed in reading only with the greatest difficulty were recorded, and in 1896 an English school physician, Kerr,[2] and an English ophthalmologist, Morgan,[3] independently published case reports of reading disability in children of "normal intelligence." Morgan considered the condition to be a specific disease entity and gave it the name of congenital word blindness, by which it has been most widely known since his reports. It is interesting to note that much of the early observation in these cases came from the ophthalmologists; naturally, a distorted vision was at once suspected in such cases and the aid of a specialist in this field was sought. A

1. Berkhan, Oswald: Ueber die Störungen der Schriftsprache, Arch. f. Psychiat. **16**: 3, 1885.
2. Kerr, James: The Howard Price Essay of the Royal Statistical Society, June, 1896.
3. Morgan, W. P.: A Case of Congenital Word Blindness, Brit M. J., 1896-1897, p. 1378.

second English ophthalmologist, Hinshelwood,[4] studied a series of cases intimately and compared them critically with cases of acquired word blindness; i. e., the loss of ability to read which follows in certain cases of local brain destruction by hemorrhage, softening tumor and other destructive organic processes. On the basis of this comparison, Hinshelwood hypothecated a congenital defect of development of the brain area for registration of visual memories of words, and this envisagement of the reading disability as a result of faulty development of part of the brain has maintained its influence to a considerable degree in medical circles to the present time. Many psychologic studies have been made of these cases and certain observable functional variants, such as unstable attention and short memory span for letters, have been recorded with at times an attempt to explain the disability as a result of such conditions. In more recent years, as the views of the functional school of psychiatrists have spread, their view of the almost universal causative influence of emotional disturbances has been carried into the field of children's difficulties of every type, and in the child guidance and mental hygiene clinics observed emotional variants when associated with special disabilities have often been assumed to play an etiologic rôle.

The assumption of a certain degree of intellectual defect as the explanation of reading disability is easy of rebuttal but apparently most difficult of eradication. Many of these children are good at arithmetic; they do not show any defect in reasoning or in judgment for their age; they often appear bright and alert and learn very quickly such material as is presented to them by ear, and some are good spellers. There are, moreover, a number of cases recorded of individuals who suffered severely with this disability in their earlier years in school but who overcame it and ultimately demonstrated a very high degree of intelligence. It should be remarked here that Hinshelwood in his use of the term "congenital word blindness" restricted it to a narrow group. He says that the term "should be reserved for the really grave degrees of defect which manifestly are the result of a pathological condition of visual memory center and which have proved refractory to all ordinary methods of school instruction." Such

4. Hinshelwood, James: Congenital Word Blindness, London, H. K. Lewis & Co., 1917.

a criterion is obviously unsound. No pathologic condition of the visual memory center has as yet been demonstrated, and "ordinary methods of school instruction" may cover a multitude of sins.

The assumption of a local brain defect is more difficult to refute. So far no necropsy reports in cases of congenital word blindness have been made, and hence no concise information is available on this point. The assumption rests, however, on the parallelism which exists between the symptoms of acquired word blindness due to destruction of parts of the brain after education is complete and the symptoms of this specific disability. No one can deny that the parallelism is often very exact, but in the closely related field of speech, Marie [5] has called attention to the fact that the results of lesions in adults after acquisition of speech cannot be directly applied to children in the plastic period of acquisition. Marie emphasizes that destructive lesions in the so-called speech zone in children do not prevent the acquisition of speech and considers that, in the event of destruction of such areas before training is accomplished, there results an education of other areas for this purpose. This view, together with the facts already quoted concerning complete recovery from reading disabilities of fairly severe grade, must be held to militate against the hypothesis of a congenital brain defect.

In January, 1925, it was my good fortune to direct a mental hygiene clinic in a semirural community in Iowa.[6] To this clinic 125 school children were referred for various reasons, and of these fifteen appeared to me not only to be retarded in reading for their age and less apt in this than in their other studies but also to show certain similarities in the errors which they made in attempting to read. One of these cases would fit the measure for the congenital word blindness of Hinshelwood, and the others of the group seemed to form a more or less continuous grading between this extreme and the normal. The group, moreover, showed a distribution throughout a wide range of intelligence and could by no means be looked on as defectives. The distribution, as measured by the Stanford-Binet tests and the range of obtained intelligence quotients, was

5. Marie, Pierre: Presse méd. **30**: 177 (March 1) 1922.

6. Lyday, June F.: The Greene County Mental Clinic, Ment. Hyg. **10**: 759 (Oct.) 1926.

from 71 to 122. In passing it may not be amiss to call attention to the fact that these tests themselves must be called in question, when applied to such a group, for three reasons. In the first place, the standards or norms have been determined by application to a large series of children of whom presumably only a small proportion had any reading disability, and hence the standard is an unjust one for them. Secondly, the application of the test itself in places depends on printed material and hence directly penalizes the score of a child who has not learned to read. A third factor that probably also operates is that the intake of a child who does not read easily is naturally much more restricted than that of others, and differences in his word storage as evinced perhaps in vocabulary tests would be expected. That such paucity of word storage and of information ordinarily acquired through reading need not relate to the potential capacity of the individual, an estimate of which is the aim of the Binet methods, is axiomatic. A tentative estimate of the degree of these penalties has since been made.[7] Another observation of interest in this group was the relatively high proportion of boys to girls—thirteen to two—and this is apparently also true of stuttering.

A short series of tests was carried out in the field examinations in this group of cases, and these were much elaborated by an intensive study of the very severe case seen later at the Psychopathic Hospital. The results of this study were reported by me[8] in 1925. Certain features which seemed to be common to the group were: (1) difficulty in differentiating p and q, and b and d; (2) a striking tendency to confuse pallindromic words like was and saw, not and ton, and to reverse paired letters or even whole syllables or words in reading so that they were read from right to left instead of from left to right; (3) a considerable degree of capacity to read from a mirror—one boy actually read faster and with less mistakes with a mirror than without, and (4) a greater facility in producing mirror writing, i. e., in writing to the left with complete antitropic reversal of all letters. It was easily demonstrated that these children did not have any visual defect in the ordinary sense and moreover that they

7. Durrell, D. D.: To be published.

8. Orton, S. T.: "Word-Blindness" in School Children, Arch. Neurol. & Psychiat. **14**: 581 (Nov.) 1925.

did not have any defect in the second level of brain function in the visual field; i. e., they could make adequate and proper use of visual memories of objects, calling the names of objects and pictures promptly and quickly. Indeed, the boy with the very severe degree of reading disability who could read only a very few simple words correctly although 18 years of age was able to make a score on the Healy pictorial test (which requires rather judicious use of visual imagery at the objective level) that was equaled only by the record of superior adults.

It is evident that it is at the third level of visual elaboration where association between the printed or written word and its meaning or concept takes place that a dysfunction exists in these cases, which in the very severe case was practically complete. There is no difficulty with auditory memory—indeed, many patients have an unusually keen auditory memory—and concepts are readily built from material presented verbally, but such concepts are not aroused by the visual presentation of the corresponding printed or written word. Some factor has operated here to prevent the normal acquisition of prompt and facile associative linkage between words when visually presented and the corresponding concept and, in reverse order, in many cases, with the associative linkage between the concept and its graphic counterpart, as is shown not only in poor handwriting and misspelling but in extreme cases often by the construction of a wealth of neographisms, as in the case that I reported.[8]

These observations focused our attention on the third visual elaborative level of the brain as of primary importance in any attempt to understand the physiologic basis of these conditions, and one rather striking difference which is demonstrable between this and the lower levels of visual function seemed to offer a key to the problem. The first level serves to give awareness that a visual sensation comes from without and is not a recalled memory of things seen; in psychologic terms, this level furnishes the element of external awareness in sensation. This function, without much question, resides in the area striata or calcarine cortex of the occipital lobes. The second level, that of objective memories, serves as the storehouse for visual impressions of objects which have been seen. This function

probably resides in the second type of occipital cortex which surrounds the calcarine or striate area. Up to this point the two hemispheres of the brain apparently work in unison to produce a single conscious impression; i. e., the messages relayed from the eyes to the two sides of the brain are fused so as to give only one impression. This is brought into relief by the fact that neither of these functions is entirely lost as a result of the destruction of either hemisphere; a bilateral lesion is required to suppress the function of either the first or the second visual platforms. At the third or associative level, however, destruction in one hemisphere may result in complete loss of the associative function, resulting in inability to read (acquired word blindness), while destruction of exactly the same area in the opposite hemisphere will not give rise to any symptoms whatever. That hemisphere in which destruction produces loss of the associative function is called the dominant hemisphere, and may be either the left or the right, according to the side which habitually initiates the motor responses of the individual. In other words, it is obvious that the visual records of one side only are used in symbolic association and those of the other are elided or inactive in this process.

Structurally, however, there is no such contrast between the two hemispheres. The nondominant associative area is as well developed in size and complexity as is the dominant, and current neurologic belief (neurobiotaxis) would imply that this silent or inactive area must have been irradiated equally with the active to produce an equal growth. Such an irradiation, moreover, would presumably leave behind it some record in the cells of the nondominant side which one may call an engram. The engram in the nondominant side would be opposite in sign, however, from that of the dominant; i. e., it would form a mirrored or antitropic pattern. Under usual circumstances only one of these reciprocally paired engrams operates in association with the concept in reading, as is shown by the facts of acquired word blindness already cited, and its antitropic or mirrored mate is elided or remains inoperative. If, however, the physiologic habit of complete elision of these engrams of the nondominant hemisphere were not established, their persistence might readily serve to explain the failure to differentiate between p and q

and between was and saw, and also to account for facility in mirror reading and mirror writing, and thus to explain those confusions of direction which have been extensively recorded in the literature and which as here described seemed to characterize all the cases of my own series. Since this conception of the disability as a physiologic variant differs so widely from the pathologic moment known to result in acquired word blindness, I have felt that the use of the term congenital word blindness was misleading and have offered [8] the term strephosymbolia—twisted symbols—to demarcate better the series of cases showing this typical symptomatology.

This preliminary study thus led me to believe that the reading disability forms a graded series in severity; that it is not generically related to general mental retardation; that it is explainable as a variant in the establishment of the physiologic lead in the hemispheres rather than as a pathologic condition and, as a corollary of the latter view, that proper methods of retraining, if started early enough, may be expected to overcome the difficulty.

To put these beliefs to the test, funds were asked of the Division of Studies of the Rockefeller Foundation, and a grant was received from it for the purpose of extending our studies. Under this grant the work was carried forward with a group of research assistants in the laboratories of the Iowa State Psychopathic Hospital from January, 1926, until I severed my connection with that institution in October, 1927. The full reports of this work are still in preparation and they will not all be available in print for some time. As a summary of the studies I may say, however, that the tenets of our theorem as given above have been abundantly supported. We have complete records of 175 children referred from the schools of Iowa City and from a number of communities of the state which were visited by our Mobile Unit, who were retarded in reading with regard both to their actual age and to their mental age and who constituted a group with selective difficulty in this subject of sufficient degree to be a significant factor in their school progress. These have been checked against similar examinations in 120 normal readers,[9] and they bear out strikingly the

9. Monroe, Marion: Methods for Diagnosis and Treatment of the Reading Disability, to be published.

importance of the tendency to reversal in the direction of reading as a cardinal factor in the reading disability. Errors in vowels and in consonants and a variety of other observed errors, while needing corrective training, may be considered largely a secondary defect of the learning process resulting from a lack of practice in reading because of the obstacle in recognition interposed by the reversals. In the course of these observations our records have made possible the construction of a series of diagnostic tests which will apparently clearly differentiate cases of this reading disability even in the lower grades from the normal readers and at the same time will serve as a guide to retraining methods.

Our extended studies have not only borne out our conviction that these cases form a series graded in severity from the mild case in which spontaneous correction occurs under the ordinary teaching system to the extreme case in which practically no reading facility is acquired without special instruction, but they have also given evidence of the much greater numerical incidence of this condition than has been recognized heretofore. Various authors have estimated the total number of cases at from 1 per thousand [10] to 7 per thousand.[11] Bachmann [12] notes that this wide discrepancy rests on the range of severity included in the concept of congenital word blindness by various writers. With as loose a concept as that of Hinshelwood [4] there is small wonder that the number of cases reported should vary within wide limits. Our studies are based on objective criteria—the number of reversals in reading, the ratio of mirror reading time to reading time of normally oriented text, the level of reading performance compared with expectations for mental age and competence in other subjects—and we feel that they give not only a diagnostic selection of the group but also a measure of the severity in individual cases, obviating the necessity of arbitrarily deciding whether difficulty in learning to read in a given case is severe enough to determine its inclusion in the category.

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10. Thomas, C. J.: Congenital Word-Blindness and Its Treatment, Pub. Health, May, 1908.

11. Warburg, F.: Ueber die angeborene Wortblindheit, Ztschr. f. Kinderforsch., 1911, number 4.

12. Bachmann, Fritz: Ueber kongenitale Wortblindheit, Berlin, S. Karger, 1927.

As measured by this standard, the number of cases really takes on numerical importance from an educational standpoint. None of our studies were made with the purpose of an accurate numerical survey in mind, but the indications of our records are that children suffering from this condition in a degree sufficiently severe to be a really significant obstacle to school progress formed at least 2 per cent of the total school population in every community visited, while in some this percentage was more than doubled. This striking difference in numbers we feel to be related directly to the teaching methods employed. Of two communities fairly comparable in the constitution of their population, we found the percentage in one to be more than double that of the other. The school system that gave the lower figure used the modern sight reading plan to some extent; but when children did not advance by this method other procedures, including phonetic methods, were used. In the school with the higher incidence, the children were not permitted to learn the alphabet and hence to attempt phonetic synthesis of words until they had learned ninety words by sight. The enthusiasm with which the sight reading methods are hailed in many educational circles is probably justified for those children who have a well established unilateral dominance when they begin to learn to read. In them the acquisition of reading seems to be hastened by the sight method. In the children with a reading disability, however, who apparently form no mean fraction of the whole, this method is obviously unsuited and may, we believe, prove a very serious obstacle.

Our concept of strephosymbolia as a physiologic variant rather than as a general mental defect or a specific brain defect naturally gives a decidedly better prognosis, and there is not only good theoretical basis for the belief that the disability can be corrected and the children taught to read but there is also to be derived from the theory a path of attack for such retraining. If confusion in the direction of reading forms the obstacle to proper association of the presented word with its meaning, the obvious corrective measures should be aimed at in training for consistent direction of reading, which probably infers the consistent selection of one of the paired set of visual engrams for associative linkage with the auditory word memories.

One very valuable aid immediately suggests itself here, and that is the inclusion of kinesthetic directional training in the building of associations. In general, the reeducation methods which we propose may be said to be based on training for simultaneous association of visual, auditory and kinesthetic fields; i. e., tracing and sounding the visually presented word and maintaining consistent direction by following the letters with the finger during sound synthesis of syllables and words. This use of the finger seems to be tabu in the modern teaching of reading, and yet it offers a ready means of correcting a tendency to reversals.

Our own retraining experiments are not as yet extensive, but they are exceedingly promising. In one instance, eight children were under individual instruction along the lines here indicated for a period of eight weeks. At the beginning of this experiment the children were retarded in reading below their mental ages on an average of three years. During the six weeks' period, every child of the group gained at least a full year's facility in reading and one gained two years. We have also noted a marked improvement in children's performance in other school subjects as their reading improves under this special instruction.

Another phase of the problem which has interested me tremendously is the relation of a variety of emotional disturbances observed in certain of these children, and the effects which such an unrecognized obstacle to progress in school may have on the personality of the child. In my first series of cases [8] I recorded what I thought to be four types of reaction to the disability: the apathetic, the emotionally blocked, the inferiority pattern and the antagonistic or paranoid. McCready [13] has recorded his support of this grouping, and also reports that he finds the paranoid group furnishing many disciplinary problems in the schools. A further report of our own studies of this phase of the problem is in preparation.[14]

Not infrequently children with marked strephosymbolia are also stutterers. In this connection it is interesting to note that Berkhan [1] has likened the reading disability and the frequently associated writing

13. McCready, E. B.: Defects in the Language Zone in Children, J. Psychiat. **18**, October, 1926.
14. Orton, S. T., and Sprague, G. S.: To be published.

disability to stuttering. From our envisagement of this difficulty as a confusion in cerebral dominance has come also an hypothesis of stuttering as derived from a comparable difficulty. Reports [15] of our work with stutterers have just begun to appear in print and others are to follow soon. Here, again, retraining experiments are not extensive but some of them are highly suggestive. This phase of the work must, however, be left for a later report.

Finally, I think that it can be stated today that the reading disability or strephosymbolia forms a fairly clear cut clinical entity which can be diagnosed by appropriate examination methods; that it is not related to feeblemindedness and may occur at any intellectual level, and that a very considerable degree of prognostic optimism is warranted when proper training is instituted early and is conscientiously carried out.

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15. Orton, S. T.: Studies in Stuttering: Introduction, Arch. Neurol. & Psychiat. **18**: 671 (Nov.) 1927. Travis, L. E.: Studies in Stuttering: I, ibid. **18**: 673 (Nov.) 1927; Studies in Stuttering: II, ibid. **18**: 998 (Dec.) 1927. Travis, L. E., and Fagan, Leo: Studies in Stuttering: III, ibid., to be published.

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NEUROLOGICAL STUDIES OF SOME EDUCATIONAL DEVIATES FROM IOWA SCHOOLS*

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The elementary studies taught in the first years of school are so simple a task for the brighter children that we are wont to consider that any child with an adequate mind even though he may belong to the dull majority should be able to encompass them. In other words we feel that any child who is not grossly defective should be able to learn simple reading, writing and spelling. In general this is true but like all other generalities it has its exceptions and these exceptions prove to be of unusual interest. The educational deviate is that child who though of average general intelligence yet cannot learn in certain restricted fields such as reading or writing or spelling under the ordinary methods of teaching. That this is a deviation and not a defect is shown by the fact that such children often respond very quickly to methods adapted to their particular learning needs.

As I have elsewhere pointed out[1] early academic education consists largely in adding the visual element to an auditory training that is already well under way. Before a child enters school he has already stored by auditory implantation the meaning of many words and has

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1. Amer. Neurol. Assoc., Washington, D. C., May 1, 1928. Arch. Neurol. and Psych. March, 1929.

learned to use them as a guide to speech but he has not as yet learned to build the association between a printed symbol (letter) and a sound or between a sequence of such symbols (word) and the corresponding sequence of sounds which constitutes the art of reading. This requires the conditioning of a new set of reflexes between the visual and auditory spheres—or the building of associations if one prefers—and this process can be shown to occur exclusively at the third or associative level of cerebral elaboration. Children who have the greatest difficulty in learning to read often have good visual control of their hands and can often make excellent use of pictorial material. This renders it obvious that their reading disability is not the result of a visual defect in the ordinary sense and further because of their use of pictures we can say that there is no abnormality in the function of the second (objective) level of cerebral elaboration. Thus the reading disability may be definitely localized as a defect in the building of association between the visual and auditory spheres at the third functional level and hence is to be regarded as a problem in which an understanding of the neurological background is of great importance.

In January, 1925, with several members of the staff of the Iowa State Psychopathic Hospital I held a clinic in Jefferson, Greene county, Iowa,[2] as an experiment in the extension of a mental outpatient service. To that clinic were referred 125 school children who were in some degree problems of various types in the eyes of their teachers. One of these was an extreme case of

2. Lyday, June F. The Greene County Mental Clinic. Mental Hygiene, 10:759 (Oct.), 1926.

reading disability or congenital wordblindness and thirteen others seemed to me to exhibit something of the same sort of symptoms as did this outstanding case. Cursory observations of this group were made in the field and the extreme case was taken to Iowa City for more careful investigation at the Psychopathic Hospital and on the basis of these studies I[3] offered a tentative explanation of the reading disability interpreted by our knowledge of cerebral physiology and also outlined methods for trial in retraining. To enable further study of this problem and to put the training methods to a test support was asked from the Rockefeller Foundation and a grant was received which enabled two years of intensive work with a specially appointed research staff. The results of this extended work are naturally too voluminous to be recorded here but it will suffice to say that my earlier views concerning the disability were amply supported and enough training experiments were carried out to warrant considerable optimism concerning treatment.

In normal children there is usually considerable difficulty in fixing the association of those letters which have two or more sounds such as the s and k sounds of c, the hard and soft g and the varying sounds of the vowels. This will be readily understood when we recall that one of the fundamental rules of the conditioning of reflexes is constancy of presentation between the stimuli to be associated. Where a variable is present the association is more slowly acquired and less

3. Orton, Samuel T. "Wordblindness" in School Children. Archives of Neurology and Psychiatry, 14:581 (Nov.), 1925.

fixed. In the reading disability cases such loose linkage between the symbol and its sound particularly in the earlier years in school is very apparent. An explanation of this seems to be forthcoming in the confusion which exists in such cases between reversible symbols such as b and d and p and q. In one of my more recent cases b and d are quite interchangeable so that baby, bady, daby and dady all spell baby for him. This tendency to confusion is of course quite obvious where substitutions such as d for b are made but it is also highly probable that a comparable confusion between the correct form and its mirrored image exists with other letters but is not so readily revealed. This confusion is further complicated by a second factor which is a tendency to read in the sinistrad direction. This exhibits itself in confusion between pallindromic words like *was* and *saw, on* and *no, not* and *ton,* etc., and also in a tendency to reverse paired letters within a word as gary for gray, tagret for target, etc. Occasionally one syllable is reversed, as in tarnish, read as tarshin or the major part of a word may be turned around as when a boy reads tomorrow as tworrom. These two errors, that of confusion between antitropic images and insecurity in direction of progress are considered to be the fundamental obstacles to learning to read in the disability cases. The resulting lack of facile association between letter and sound and in building sequences of sounds from grouped letters gives rise to a wide variety of other errors—vowel errors, consonant errors, omissions, additions, repetitions, etc., but all of these, I consider to be by-products of the two cardinal ones.

We are thus faced with the problem of explaining why b and d should be confused by some children more persistently than others and why some should tend to read to the left. The restriction of the disability to the third level of cerebral elaboration considerably simplifies this problem for us. In both the lowest level which gives us external awareness of a sensation (as contrasted to a mnemonic image) and the second level which serves for objective imagery (cf. use of pictorial material as quoted above) the two hemispheres of the brain operate together and it is only at the third or associative level that a striking difference is found between the right and left hemispheres. Destruction at this level in the leading or dominant hemisphere will result in marked functional loss such as aphasia, agraphia, alexia, etc., which exactly similar destruction in the same area of the non-dominant hemisphere gives no clinical result. These facts clearly indicate that for these associative functions the sensory record in only one hemisphere is required and by inference that the record in its mate is elided or inoperative and our explanation of the confusion which exists in these children between reversible symbols is that the image in the non-dominant hemisphere has not been properly elided and hence operates to produce confusion with its opposite which is recorded in the other hemisphere. Further evidence in support of this view is the fairly frequent spontaneous production of mirror writing by these children. Whether or not this factor is the same as that which determines sinistrad progress or whether both may exist independently and produce the most severe

grades of disability only when they coexist cannot be answered as yet.

This explanation of the reading defect as a failure to establish complete unilateral cerebral dominance has naturally called attention to other possible expressions of such a condition such as developmental apraxia, congenital aphasia, stuttering and defects of spelling and writing. In one of my Iowa cases a twelve year old school girl had led her class in spelling in Texas but on moving to Iowa was failing in spelling. The explanation of this apparent paradox lay in the fact that in Texas her spelling tests were all given orally while in Iowa she was required to write her spelling lessons and apparently in her particular case the interplay between the visual and auditory was facile in the control of speech but not as a pattern for writing. Again in a case which I have recently seen in Massachusetts a boy read for me two pages of fairly difficult text with only three minor errors yet on attempting to spell selected words from the same text he made twenty-five serious errors some of which were of quite a bizarre type such as qulkey for quickly and trunth for through. Obviously here again the visual records while adequate as a path of intake were not freely enough available to serve as a guide to spelling and in this particular case there was also a marked lack of visually acquired words carried over into speech.

I think we may assume on a priori grounds that a free interplay between the visual and auditory memories is essential for the acquisition of reading since the child learns words by ear first and on entering school he merely acquires the means

of arousing these verbal memories by way of visual symbols. He knows cat as a word sound long before he knows c-a-t as its visual counterpart. Again in spelling it is obvious that our ability to recall the silent letters in many words is a function of visual memory. One frequently sees this put to use by insecure spellers who must write out a word and "see how it looks" to be sure of its spelling. Other evidences of lack of a free interplay between these two all important functions is readily observed in both writing and speech defects but we cannot assume that these children, merely because they differ from the usual, are either less intelligent or less educable. They form the group to which I have applied the term educational deviates to denote those who vary from the standard and who therefore require special methods of training. That this variation is not related to mental defect in the case of the reading disability is abundantly demonstrated by our findings[4] in 175 cases from the Iowa schools in which were represented all levels of intelligence quotients even as measured by the Stanford-Binet tests which I consider to give a quite inadequate estimate of intelligence in children suffering from these special handicaps.

One of the interesting phases of this work is yet to be reported.[5] This has to do with the effects on the personality of the child which accrue from an unrecognized handicap. Obviously when a bright child looks at was and miscalls it saw the teacher or parent is apt to interpret the error

4. Monroe, Marion. Diagnosis and Treatment of the Reading Disability. Genetic Psychology Monographs. Oct., 1928.

5. Orton & Sprague. Some Psychiatric Observations in Strephosymbolia. To appear later.

as a result of lack of effort or inattention. Later as he falls progressively behind his classmates in reading he is usually exposed to well meant but misunderstanding pressure by both parents and teacher and also to the characteristically heartless raillery of other children. Several psychiatric reaction patterns to this pressure have been observed but perhaps the most illuminative fact is the change of attitude which almost always follows when such a child is told that there probably is a real reason for his difficulty and that he is not to be regarded merely as "lazy" or as a "dumb-bell".

In my first study of these reading cases in Greene county (loc. cit.) I was impressed with the large number encountered. Our further studies, however, have shown that that group was not exceptional. In round numbers our findings in Iowa indicate that approximately 10 per cent of all children who are referred to a clinic by their teachers because of poor school work have a varying degree of this handicap and further that the disability exists in sufficient degree to determine a definite retardation in school progress in at least 2 per cent of the total school population in every community which our Mobile Clinic visited. In one county this number was more than doubled and our interest was naturally drawn to the educational factors which might account for this. The county with the higher number of cases was one in which the "sight method" of teaching reading was used exclusively at first and theoretical considerations[6] lead

6. Orton, Samuel T. The Sight Method of Teaching Reading as a Source of Reading Disability. Jour. Educ. Psychol. Feb., 1929.

us to believe that this pedagogical procedure is in large part responsible for the greater number here.

A number of retraining experiments were instituted at the Psychopathic Hospital and in various communities in Iowa. The methods employed were adopted with a view to the neurological concepts involved and the results give excellent promise that the disability can be overcome by special instruction. These methods as far as they apply to simple uncomplicated reading retardation are discussed in some detail in one of our reports.[7] In most instances however one of the most important features of retraining is gaining the confidence and spontaneous interest of the child and a thorough study of the attitudes and defenses which have been engendered by his difficulties is often of as great value as the actual technical retraining. In cases of retarded speech and developmental apraxia (extreme clumsiness) the problem of cerebral dominance is the cardinal issue and such children also give promise of great improvement under properly controlled special training. Not infrequently the question of native handedness and the effects of mistraining of a naturally left-handed child are matters of highest import here. In one such case which I have seen since leaving Iowa a boy of eleven had spent five years of rather unproductive work in an excellent private school. He read with ease and considerable rapidity and was spontaneously interested in reading as an acquisitive method. His speech, spelling and writing, however, were all on an ex-

7. Monroe, Marion. (Loc. cit.)

tremely poor plane and his efforts to express himself were accompanied by an increasingly severe "motor overflow" which resulted in a condition of exaggerated fidgets and a very apparent heightened nervous tension. Special tests revealed that his best motor facility lay unquestionably in his left hand although he had up until this time been trained exclusively with the right. A shift to the left with other special means of retraining was recommended and after only eight weeks of intensive work along these lines he shows more improvement in handwriting than he had in the five years of previous training. He is also gaining rapidly in speech, his spelling is improving and he is under much less nervous tension when attempting to talk.

As a whole these studies which were in very large part carried out on Iowa school children have opened the way to a field of study of really absorbing interest and I think to one of immediate practical importance.

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A PHYSIOLOGICAL THEORY OF READING DISABILITY AND STUTTERING IN CHILDREN*

BY SAMUEL T. ORTON, M.D.

IN 1925 there was published by the writer a preliminary report of a study of a group of children who were retarded in reading and who seemed to him to show a complex of symptoms which differentiated them from normal readers[1]. At one extreme of this group was a case of such severity that it would be universally characterized as congenital word blindness, while the remainder seemed to form a graded series extending from that to the normal. In the past there has been a tendency to look upon the more severe cases as pathological in nature and the less marked ones as merely cases of slow acquisition of reading, but there has been no criterion by which these two groups could be separated except the opinion of the examiner. In my report it was pointed out that there were certain errors which seemed to characterize the reading attempts of these children and which suggest a physiological rather than pathological basis and a tentative explanation was offered on the basis of confusion in cerebral dominance. Following that study an extension of these observations was made by a grant from the Division of Studies of the Rockefeller Foundation. This work was initiated in January, 1926, under my direction at the Iowa State Psychopathic Hospital, and continued until October, 1927. For this further study 175 children were chosen who showed a selective retardation in reading below

*Read at a meeting of the Boston Society of Neurology and Psychiatry, February 16, 1928.

both mental age and school grade placement. By this method of selection there was obtained a group of retarded readers without regard to the character of their reading performance and to these children was given an examination designed to discover the frequency of certain types of errors in their attempts at reading. As a control series the same examination was given to 120 children who were reading with the facility expected for their mental age and grade placement. The results of this work are soon to be published in detail[2] but I may anticipate their appearance by the statement that these studies bear out strikingly my earlier contention that reading disability forms a fairly clear-cut clinical entity which can be diagnosed by the frequence of certain types of errors and that our series of tests will also serve to grade cases according to the severity of their handicap.

The work of retarded readers is characterized by a tendency to confuse letters which are alike in form but different in orientation, as lower case *b* and *d* and *p* and *q*, and by a tendency toward sinistrad reading in which there is either misreading or complete bepuzzlement when confronted with short pallindromes like *was* and *saw, not* and *ton, on* and *no,* or in which paired letters or syllables or parts of words are read backward as when *calm* is read as *clam, gray* as *gary, tarnish* as *tarshin, tomorrow* as *tworrom,* etc. They further show a markedly greater facility in reading from the mirror than do normal children and often a much greater ability in mirror writing as well. To demarcate this larger group, which includes a much wider range than the earlier category of word blindness, I have suggested the name "strephosymbolia" (twisted symbols) as a term descriptive of the objective symptoms.

Many other errors are to be found more frequently in the work of the retarded group than

in the normals. Here may be mentioned failure to link the proper consonant or vowel sound with its appropriate visual symbol, errors caused by omission or addition of sounds, repetition of parts of a sentence already read, etc., but these I consider to be only a by-product of the failure of proper association due to the confusional element injected by reversals or by insecurity concerning direction of reading. As supportive evidence for the etiological relations of this factor of directional confusion, I may add that our retraining experiments indicate clearly that when this tendency is lessened by special drills aimed at consistent direction, there is not only a marked improvement in ability to read but also a marked change in the error picture presented so that both range and type of errors become more like those of the normal readers.

In my first report I called attention to the rather high incidence of speech disturbances in my series of reading cases and since the concept of confusion in cerebral dominance seemed to offer a point of attack on stuttering also, we have carried out some experimental studies in that field as well.

Stuttering, like strephosymbolia, occurs in graded steps from normal to extreme. The emotional element has received much attention in stuttering and has long been popular as an explanation of its occurrence. It is, of course, true that stuttering is not only more frequent but more severe in embarrassing situations and that it rarely occurs in singing or in repetition of material learned by rote. This immediately suggests for us that the difference here is related to the plane of the speech effort rather than to the emotional influence of the environment or the actual emotional content of the speech. This brings into relief the propositional element of speech and with one exception this seems to be the plane at which stuttering is most severe and

most frequent, and it is often of course in embarrassing and strange situations that the propositional effort is most stressed. The exception mentioned is oral reading; some stutterers read aloud with relative fluency, but we also have observations in several cases of our series in whom stuttering is much worse when reading aloud than in any other form of speech. A nice formulation of the influence of the propositional element in a somewhat comparable difficulty was given me by a highly intelligent case of writing disability. This was a young man for whom writing in the dextrad direction was very difficult—indeed his product was often quite illegible to himself as well as to others—yet who wrote letters home which his family could read. On question he explained this by saying that when he didn't have to *think* hard he could write better but when he had to think and write at the same time, as when answering examination questions, he couldn't write so that he could read it himself.

Our physiological studies in stutterers are not all as yet in print but part of this series of reports have appeared[3 4 5] and others are to be published soon. In summary we may say that the stuttering act is characterized by a striking failure of orderly integration of the various reflex groups which co-ördinate in the production of speech. Thus we have records in which the direction of motion of the chest and abdomen are synchronously opposed, the chest inhaling while the abdomen exhales and vice versa, thus counteracting each other so that no breath stream is passing the larynx. Again the larynx, which normally makes many up and down excursions in vocalization independently of the expiratory movements, is seen in some of our records to move in time with the abdomen or with the chest[4]. We have also found evidence of both tonic and clonic spasms in the

muscles of the vocal mechanism during stuttering. The tonic spasms show themselves in both kymographic records of the movements of the chest, abdomen and larynx and also in the fixed tones which can be shown by plotting photographic records of the speech vibrations[5]. The clonic spasms are perhaps best shown by the occurrence of a vibrato in the stutterer's speech[5]. The vibrato is a rapid fluctuation within a narrow range of pitch which is found in singing, in intoning and probably also in strongly emotionally colored speech but is not found in normal fluent propositional speech.

The relation between stuttering and the enforced training of a left-handed child to use the right hand has been frequently recorded in the literature and naturally our attention turned to the relationship of handedness to stuttering. Many tests have been advanced for the detection of the facile hand, but we soon became convinced that none of the ordinary tests were dependable because of the effects of training and imitation. Many mothers shift children who show a preference for the left hand at a very early age. In one of our cases a little girl started to talk at about the usual period and at the same time gave evidence of selective choice of her left hand. The mother, with that curious reaction which appears to hold lefthandedness as abnormal, insisted on the child's use of her right hand with her spoon, etc. Almost immediately the child stopped all efforts of speech and did not begin again for over a year and when she did begin, she stuttered badly. In another case which I have seen quite recently the stuttering was associated with a high degree of strephosymbolia. This was a twelve-year-old boy who started out in infancy to use his left hand and was shifted by his mother. His speech showed no defect until he entered school, where again his left preference was manifest and pressure was necessary to make

him learn to use his right hand in writing. Coincident with this new pressure his stuttering began. Today if a pencil is offered to him, he almost invariably grasps it with his left hand and then transfers it to his right. His father is left-handed in everything except writing and the boy carries out most of his motor acts with the left hand. In golf, however, which he has learned from his mother, who is right-handed, he uses his clubs as a right-hander does. In golf this boy shows the effect of imitation, in writing that of enforced training. An exceedingly instructive description of the influence of imitation was given me recently by a man who had been a pole-vaulter during his college course. In discussing handedness he told me that, as far as he knew, he was naturally right-handed in everything except pole-vaulting and this he did from the left. He explained this by recounting his first contact with this sport when as a high school boy he saw a single vaulter give a demonstration. This athlete was left-handed and from then until he entered college, the boy's imagination turned frequently toward vaulting; as he put it, "I could feel myself running down the field carrying the pole as I had seen it carried, and thrusting it into the ground for the lift." When he finally did appear on the athletic field this preference was so fixed that the coaches despaired of making a right-handed vaulter out of him and let him go ahead as he was inclined. Generally speaking the only motor function which is held to be of real significance as to handedness is that of writing and indeed many hospital records in aphasias and other of the alpha-privative brain diseases (alexia, agraphia, apraxia, etc.) require no further evidence of handedness than that of the writing hand. The practice is so widespread among teachers today, however, of training every child to use the right hand in writing, if it

can be done by coercion or wheedling, that very little dependence can be placed on this evidence alone. Much of the aphasia literature must be questioned for this reason and we feel that the ordinary motor tests were far from satisfactory for our purpose.

Golla[6] has reported finding differences in the time of incidence in the action currents of the two forearms on simultaneous motion which, in his case, were related to handedness. So far as I am aware, neither Golla nor any other observer has followed up this work, but it appealed to us well worth a trial for our purposes. The full results of this work will appear later[7], but in brief we have found that in clearly right-handed normal speakers, the number of times the action currents in the right arm appear first far exceeds the number of times they appear simultaneously or in the left first. In seventeen stutterers, all of whom would be adjudged right-handed by the usual tests, the records are decidedly different. In this group the currents take precedence on the left in much greater number of trials than on the right and the simultaneous records also outnumber the right markedly. Whether or not these action current patterns give a real indication of the native handedness of an individual remains to be controlled by much wider investigation, but it can at least be stated that our series of "right-handed" stutterers gave a very different action current pattern than did our right-handed normal speakers. A number of other tests were used, but these need not be detailed here.

Before presenting our current envisagement of the relationship of cerebral dominance to certain of the symptoms reviewed above, it may be well to review briefly certain of our knowledge of cerebral localization and the results of lesions in certain fields.

The central nervous system is divided into

two quite symmetrical halves of approximate equality in size. From the gross standpoint, size probably is of very doubtful importance. Variations in weight due to differences in vessels or in amounts of myelin or neuroglia might far out-weigh differences in cortical elements and thus mask really significant differences. In general, however, the gross weight of the two hemispheres is the same. Some years ago, at the

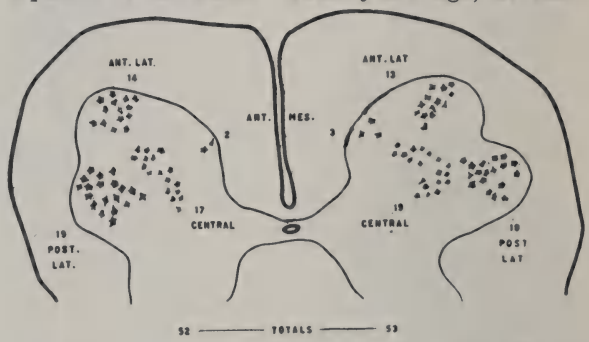

FIG. 1. Projection drawing of spinal cord to show antitropic symmetry.

Worcester State Hospital, I recorded individually the weights of the two hemispheres in a considerable series of autopsies. On reviewing such records of about 80 brains recently, I found that in the majority of these cases the protocols made record of gross lesions which nullified them for our present purpose, but there were 27 brains which fell in Southard's "normal looking" group. In these the left hemisphere was somewhat heavier in nine cases, the right in eight and their weight was equal in ten. From the microscopic standpoint we can say with considerable assurance that the two sides of the spinal cord are very exactly alike. Fig. 1 is from a projection drawing of a section of the spinal cord chosen from among a set of routine teach-

ing slides. No attempt has been made in this to reproduce exact outlines of cells but their number and position has been carefully followed and the figure speaks for itself. In the brain our information is less exact, but we may safely say that no readily observable differences between the hemispheres occur in lamination, in numbers, in size or in spacing of brain cells. There are, however, striking differences when we compare the functional activity and relations of the two hemispheres field by field.

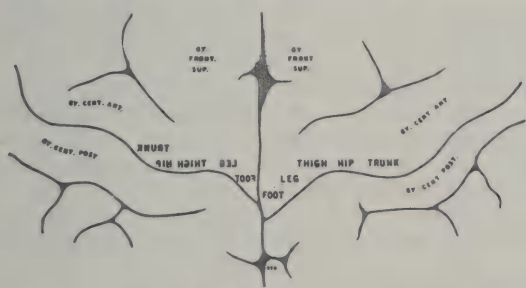

FIG. 2. Antitropic arrangement of functional centers in motor area.

The motor cortices are strictly unilateral in their function and they are strictly independent. No further evidence need be cited for this than that of the unilateral paralysis which follows lesions of the contra-lateral precentral or capsular regions. They are also antitropic, i. e. each is arranged in the mirror pattern of its mate and I think we can consider it safe to assume that any irradiation pattern of one hemisphere will give a motor response which will be the exact mirror counterpart or antitrope of that resulting from an exactly similar irradiation pattern in the other hemisphere. This relationship is indicated in Fig. 2.

A similar antitropic unilateral independence is to be seen in one sensory cortical field. This

is the postcentral zone, which is intimately related to the motor area and which probably serves for the registration of the epicritic fraction of the exteroceptive and proprioceptive stimuli brought in through the spinal cord. As in the motor cortex, where separate control of the two paired halves of the body would seem to require separate functional relations, so here in the postcentral cortex the physiological demands would seem to necessitate functional divorce of the two hemispheres. In the case of these spinal receptors it is important for proper responses for the brain to be informed not only that a thumb has been burned but which thumb it is.

In the case of one of the projicient exteroceptors (i. e., those sensory mechanisms which are influenced by stimuli arising at a distance from the body,—smell, vision and audition,) there is very little accurate information. This is the sense of smell and the paucity of knowledge here rests in part on the relatively small use that is made of this sense and in part on a lack of interest on the part of recording observers. Of vision and audition we have better information, however. It is obvious that in these two sensations, in order to insure adapted responses to environmental changes, a sensory stimulus arising in one eye must either fuse its charge with that arising in the other eye or enter into rivalry for the control of the final common paths. In certain of the lower animals—notably the achiasmic—rivalry probably occurs, but Sherrington's[8] careful study of retinal flicker has established fusion as the pattern of the human visual cortex and this is probably also true of audition. That the two hemispheres act as one by thus fusing the effect of bilateral irradiation to produce a single conscious impression seems also well supported by the fact that at the lower levels of sensory elaboration a bilateral lesion is necessary for loss of function. A unilateral

lesion causes no demonstrable loss in central vision for example and one side of the brain is apparently no more important than the other in this respect. In audition, likewise, apparently a bilateral lesion of the transverse temporal gyri of Heschel is necessary to produce cortical deafness.

We must, however, bear in mind that there are several functional levels of sensory elaboration in both vision and audition and, as we shall see, these inter-hemispheric relations are not alike at all levels. The first cortical platform of vision and audition is the first point of each system at which activity is associated with consciousness. If the arrival platform of both hemispheres (which we have reason to believe is restricted to the calcarine zone or area striata in vision and to the transverse temporal gyri in audition) be destroyed, the results are cortical blindness and cortical deafness, respectively, in which no conscious response to light or sound remains. If, however, these areas be intact but extensive unilateral lesions occur in the higher platforms, the result is mind blindness or mind deafness in which the individual can see or hear things sufficiently to guide coarse motor acts (e. g., avoid collisions) but in which things seen or heard have no meaning. The classical description of Munks' dogs give an excellent picture of this condition in vision. I think that we may assume that this arrival platform or first level of functional elaboration in vision, aside from acting as a very exact guide to motor responses to current sensations yields in consciousness only that fraction of the visual function which serves to make us aware of the external origin of a sensory impression as contrasted to a mnemonic recall. In psychological terms, it furnishes the perceptive fraction of sensation but not the apperceptive or associative. For these reasons I

have suggested the name "visuo-perceptive" for the calcarine field[1].

When both the arrival platforms and the next adjacent cortical fields are intact but the third level of elaboration is lost by destruction still higher in the cortical pyramid, we encounter the conditions known as "word blindness" and "word deafness," in which vision and audition in the ordinary sense are intact and in which the use of objects and source of sounds can be interpreted but where the printed or spoken word has lost its meaning. Such a patient can recognize objects by vision and put them to their proper use but cannot read their name from print (alexia) and usually cannot call them by name (visual aphasia) or, in the auditory field, he can recognize a voice from the bark of a dog but cannot understand the spoken word.

These losses are exclusively at the third or symbolic level and when they occur they bring into relief the functions which are the additive result of activity at the first and second levels. As we have seen, the arrival platform probably furnishes to consciousness only the perceptive fraction of sensation, but when the second level is also intact there is added to this the recognition of meaning of objects seen but not that of symbols. We have reasons to believe that this second functional addition takes place in the large field of common occipital type of cortex encircling the area striata and for this I have suggested (loc. cit.) the use of the name "visuo-recognitive." It is to be emphasized here, however, that losses do not occur in either the first or second levels of elaboration of the visual or auditory sensory material unless the lesions be bilateral. Not only do the corresponding areas of the two hemispheres at these levels seem to work in unison to produce a single conscious impression, but apparently either is adequate for

this result, as is shown by the fact that unilateral lesions do not destroy the function here and there is no evidence to suggest that either hemisphere is more important than the other. At the third or symbolic level, and here we may include both the sensory input (understanding the spoken word and reading the written word) and its motor congener (speech and writing), the situation is quite different. Here we find that a unilateral lesion is sufficient to destroy the function and moreover that the particular hemisphere plays a deciding part in the result. A destructive lesion in the so-called "zone of language" which corresponds closely with this symbolic level is only of importance in case it occurs in the dominant hemisphere and an exactly symmetrical lesion of the opposite or nondominant hemisphere does not result in any observable clinical symptoms. Up to this point our outline has followed the pretty generally accepted views of cerebral function. Although there are many minor differences of opinion in this field, especially as it bears on exact functional localizations and on the predestination of certain cortical structure for certain functions, yet I think the general story as presented would bear the endorsement of the greater number of students of human cerebral localization. Fig. 3 is a brain map giving in diagrammatic form the major areas here discussed. This is not intended to represent exact demarcations of these cortical fields. Indeed, except in the case of the calcarine or visual arrival platform, the transverse temporal field or auditory arrival platform and the precentral or motor area, no abrupt changes of cortex type are demonstrable. The chart does, however, give the general regional distribution and extent of the characteristic cortices. The legend shows in the fourth column the interhemispheric relations which are of so much interest to us in this discussion.

As has been indicated above, however, there is no such striking difference in the structural development of the two hemispheres as we have seen to exist in their functional relations. In general the association areas of the non-dominant hemispheres, resting under cover of their title of "silent areas," have received very little consideration. If, however, we are to accept the tenets of neurobiotaxis, which hold that the growth and development of nerve cells is directly related to their irradiation by nerve currents, we must infer that the silent areas of the non-dominant hemisphere have received an irradiation approximately equal to that reaching the dominant in order to account for their approximately equal growth. Granting this, I think we may safely assume that such an irradiation will leave behind it a record or engram in the non-dominant hemisphere as well as in the dominant. The fact that losses in the language function (verbal understanding, reading, writing and speech) follow only when the dominant hemisphere is attacked, however, leads us to believe that only that pair of engrams are used in these functions which are recorded in the dominant side. Their counterpart must therefore be considered to be inactive in these processes, i. e., there is elision of one group at this functional level.

There is, however, for some cortical functions strict antitropism (i. e. right and left pairing) and it is only in those areas where fusion seems to occur (first two elaborative levels of the projicient extero-ceptors) where such apposition is not apparent in function as well as in structure and many of our data in cases of strephosymbolia offer evidence that this antitropism operates at the symbolic level of the visual field. Here I may quote again the cardinal points which characterize the performance in cases of reading disability;—confusion in orientation, re-

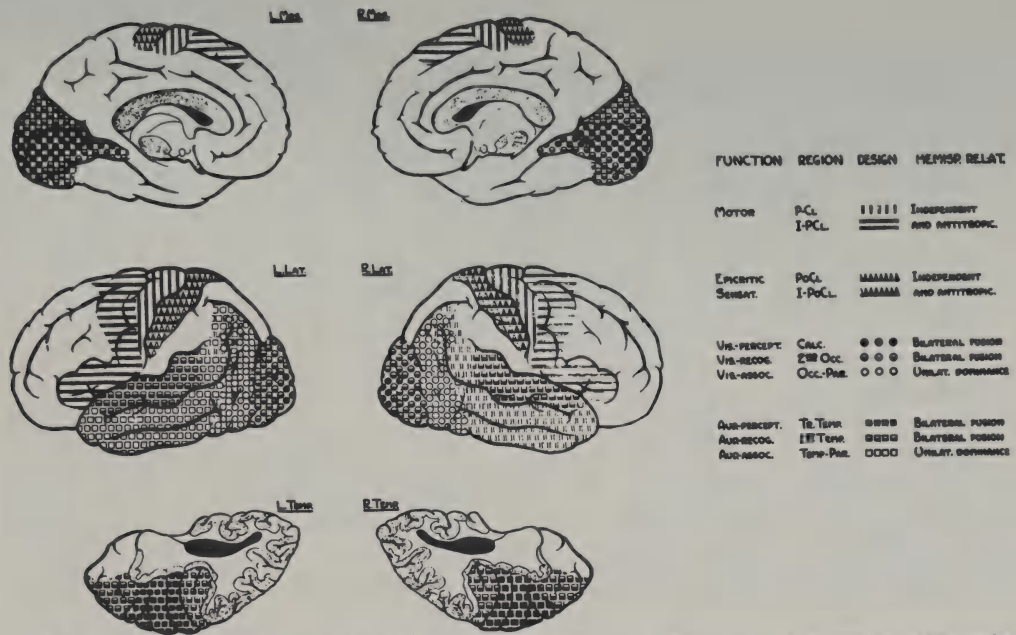

FIG. 3. Diagrammatic map of brain showing approximate extent and distribution of the cortical fields under discussion.

versal of sequence, mirror reading and mirror writing.

In skeleton, then, my theory of the obstacle to the acquisition of reading in children of normal intelligence which results in the varying grades of reading disability is a failure to establish the physiological habit of working exclusively from the engrams of one hemisphere. As a result there is incomplete elision of one set of antitropic engrams and there results confusion as to direction of reading which serves as an impediment to facile associative linkage with the auditory engrams, which, during the learning years at least, carry the meaning.

In stuttering the details are not quite so well elaborated, but there are several facts of suggestive interest here. We can demonstrate in stutterers a striking dysintegration of the reflex units which should operate in harmony in speech. While certain of these coördinations might superficially be likened to the results of cerebellar dysfunction, we do not encounter true stuttering as a result of acquired cerebellar lesions and the observed facts of the aphasias lead us to believe that the extensive and complicated integrations of speech are a function of the cortex and that sensory engrams of both visual and auditory implantation form an important pattern storage for the control of speech. Confusion in choice of antitropic engrams here also might result in failure of accurate synthesis of the reflex patterns which enter the speech act. The connection here is not so direct, but the frequent association of change of handedness, especially in writing, with stuttering is suggestive, as are our observations of stuttering during oral reading, our records of action current patterns and the results of some of our experiments in treatment of stutterers.

Whether or not the theoretical outline for the

two conditions of reading disability and stuttering here presented will stand the test of further study and more intimate knowledge of brain function and brain structure, we can at least say that this physiological concept offers a much more hopeful prognosis than that of the agenetic focal brain condition which has been its chief precursor as a theory of the etiology of word-blindness or than the most equally intangible emotional variant which has held sway in stuttering. Our new envisagement also has suggested some distinctive lines of experimental attack on retraining which we have already found highly effective in overcoming the reading impediment and very promising in stuttering.

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AN IMPEDIMENT TO LEARNING TO READ—A NEUROLOGICAL EXPLANATION OF THE READING DISABILITY

SINCE reading forms so early an acquisition n academic education and since facility in this ubject is usually acquired even by children who quite obviously are below the average in rightness, we are prone to assume that any hild who is not grossly defective in intelligence an learn to read. Like all generalities this ssumption has its exceptions. That certain hysical defects such as very faulty vision or earing may serve as a hindrance to easy acquisition of reading is self-evident but it requires more explanation when the statement is nade that children with normal or even superior ntelligence and with normal vision and audition and even with normal use of ordinary pictorial material may yet have great difficulty in earning to read, or may even prove to be unable o learn from ordinary teaching methods. This statement is, however, demonstrably true and suggests a problem on which the neurologist nay throw some light.

That children with a specific reading disability but with normal intelligence do exist has een known in medical literature for approximately thirty years and in that period studies have been made of many cases by physicians, psychologists, and teachers. In general, however, there has been a strong tendency to differentiate between those who learn to read with great difficulty and those who never learn to read at all, and to cases of this latter group (those whom no amount of ordinary teaching will train to read) was given in 1895 the name of congenital word-blindness. This term was applied first by an English ophthalmologist and its use was suggested by the similarity between this difficulty and that of persons who had lost the capacity to read because of disease of the brain and who were known as cases of acquired word-blindness. In such cases destruction of a small part of the brain by a tumor, an injury or a hemorrhage gives rise to a practically complete loss of the power to read, and this loss exists as an isolated defect, that is, the individual does not lose the power to understand spoken words or to speak or to do arithmetic or other mental tasks. Later a second English ophthalmologist, Hinshelwood, studied more extensively a number of children who could not learn to read, and because the symptoms which they presented were so closely parallel to those of acquired word-blindness he suggested that probably a defective development of part of their brain—the so-called area for word memories—lay back of their failure. This was pure inference from comparison with the acquired cases and not only has no proof of such a development-defect been brought forward in these cases but there is strong evidence to suggest that there is no such fixed predestination of brain-areas to serve a given purpose as this assumption would entail. Hinshelwood further attempted to divide poor readers into two groups—those of congenital word-blindness who did not learn to read at all under regular school training and whom he considered to be pathological or disease cases, and those who were merely slow in learning this particular subject whom he rated as physiological and hence not as disease cases. Hinshelwood's separation into these two groups has dominated consideration of the reading disability to a very considerable degree although there have been many investigators who have felt that this division into two classes was artificial and that children of normal mind who had difficulty in reading all belonged to the same group and that the cases of "congenital word-blindness" were merely those of greater severity.

In my own work in this field I was from the first rather strongly impressed with the idea that specifically retarded readers formed a homogeneous group who differed only in the degree of their handicap and not in type. I was fur-

ther convinced that the nature of their errors in attempting to read indicated the reason for their disability, offered a means of recognizing their handicap early, and, further, might serve as an indicator for methods for training them to read. These views have now been put to the test of an extended study of a comparatively large number of cases and I think that the above assumptions are strongly supported by these further observations.

The explanation of the cause of the handicap rests on well-known facts of brain anatomy and brain pathology. Unlike many of the organs of the body, the brain is made of two symmetrical halves or hemispheres separated from each other by a deep cleft or fissure and connected only by a massive bridge of fibers. It is thus more nearly comparable to the two arms than to the heart or liver and this simile may be carried further since the two hemispheres are exactly like each other but are an antitropic right and left like the two hands. While we recognize that structurally these two halves are quite distinct, we yet know that they do not work as separate units. Nor are their relations to each other exactly the same in the various functions in which the brain participates. For example, the way the two halves function in control of voluntary motion is not like the way in which they function in the reception of visual impressions and in neither of these are their relations to each other the same as in reading and writing. This will be more clear from a consideration of these various functions separately.

With regard to control of voluntary motion, each hemisphere acts on the opposite side of the body exclusively. While there is exceedingly close coordination between movements of right and left hands, for example, yet each is independently governed by nerve-cells situated in a narrow strip of gray matter, the so-called motor area, of the opposite hemisphere. This independence of the two sides is demonstrated when disease or injury destroys the motor area of one hemisphere. This results in a loss of voluntary movement of the opposite half of the body but does not interfere with voluntary movement on the same side. Thus in the common one-sided paralysis which so often follows a stroke of apoplexy, destruction of the motor area or of the fibers leading from it, in the left hemisphere, paralyzes the right arm but does not affect the left. This relative independence of operation of the two hemispheres also characterizes the brain's registration of the sensation of touch. A touch on either thumb is registered in the opposite hemisphere only. This is quite in accord with the physiological needs of the situation, for in order to respond accurately the brain must be informed not only that a thumb has been touched, but also whether it was the right or left thumb.

With regard to sight and hearing the situation is quite different. Here, obviously, to enable proper response it is important that a single object or a single sound shall give rise to only a single impression and not to a separate sensation of the messages from each eye or each ear as in the case of the touch-messages from the thumbs. The nerve-fibers which run from the center for acute vision in the retina of each eye divide so that each eye is connected with both hemispheres and thus whether an image falls on either retina or on both, its message is immediately relayed to both hemispheres of the brain. A comparable situation exists in hearing. The single conscious impression that results from this double activity is probably not brought about by inactivity or elision of the effect produced in one half but by the fusion of the effect in both. This is supported by physiological studies and also by observations where disease or injury has caused destruction in that part of one hemisphere which receives messages from the eyes or ears. As we have seen above, when one motor area is destroyed a paralysis in one half of the body (hemiplegia) results but when one visual area or one auditory area in the brain is destroyed there is no loss of central vision or of hearing. Thus we must assume that either half of the brain alone is competent for sight and hearing.

We must, however, restrict the foregoing statements to the registration of the simple material brought in by sight and hearing such as objects and noises. When we reach the much more complicated processes which underlie understanding of written and spoken words we find still another type of relationship between the two hemispheres. The four activities

which constitute the "language faculty"—understanding the spoken word, understanding the printed word (reading), speech and writing—seem to be controlled exclusively from one hemisphere since destruction of certain areas of one hemisphere causes loss of one or more of these functions while destruction of exactly similar degree and in exactly the same part of the other hemisphere gives no demonstrable result. This striking difference in functional importance of the two hemispheres in the more complex functions underlying language constitutes the problem of cerebral dominance and while much of the older view of the exact pigeonholing of these functions into restricted areas, predestined for that particular purpose, is under challenge to-day, yet the general view of control of these functions from one hemisphere is practically universally accepted.

As we have seen above, however, there is no such striking structural difference between the two hemispheres as we see between their functional duties. The two halves are about equal in size and in complexity and since the studies of Dr. Kappers of Amsterdam and his followers have demonstrated that completed growth of nerve-cells is very largely influenced by the stimuli which they receive, we must assume that the inactive (or non-dominant) hemisphere has been stimulated as freely as the active (or dominant) side and we may further assume that such stimulation has left a record behind it in the nerve-cells of both hemispheres. In other words, we feel that both halves have been equally irradiated by nerve-currents and that both bear impress thereof, but since the destruction of one side brings no aftermath we believe that one of these sets of records is elided or inactive in the language-faculty and that normally a physiological habit is established of using only one set in reading, writing and speech. The two halves of the brain, however, while alike in size and design, are reversed in pattern, that is, the left hemisphere bears the same relation to the right hemisphere that the left hand does to the right hand. It seems logical, therefore, to conclude that the records (or engrams, as they are called) of one hemisphere would be mirrored copies or antitropes of those in its mate. If then there should be failure in establishment of the normal physiological habit of using exclusively those of one hemisphere there might easily result a confusion in orientation which would exhibit itself as a tendency toward an alternate sinistrad and dextrad direction in reading and in a lack of prompt recognition of the differences between pairs of words which can be spelled backwards or forwards, such as *was* and *saw, not* and *ton, on* and *no,* etc.

These alternations and confusions are exactly what characterize the efforts of retarded readers and moreover the frequency of their occurrence bears a very clear relation to the severity of the condition. Extended studies have shown that while many other types of errors occur, such as faulty vowel-sounds, faulty consonant-sounds, etc., confusion in direction bears a most significant relationship not only to reading-retardation in children of normal intelligence (specific reading-disability) but also to the amount of their handicap. In their earlier years these children have greater trouble than the average in telling *b* from *d* and *p* from *q*. Later they learn to tell these letters apart quite readily when seen alone, but are very apt to get them mixed when encountered as parts of words, or this may evince itself in written spelling as when a boy writes *bady* for *baby* and *septemder* for *september* and can not see the error on re-reading it. Still later these simpler confusions between letter-forms are entirely corrected, but errors due to wrong sequence or direction of reading are common. Here the most frequent are confusions of short pallidromic words like *was* and *saw,* as mentioned above, but we also very often find a few letters turned around in the middle of a word. Of this type my recent case-records show *pardon* read as *pradon, maple* as *malpe, story* as *sorty* and *target* as *targret.* Obviously such a failure of the printed word to call up its sounds in proper sequence forms an obstacle to arousing that auditory memory of the word to which its meaning is attached, and reading is sadly blocked. Still later in the milder cases and especially in those children who have had a great deal of intensive help from special teachers or at home, I have found a fair facility in reading accustomed words, so that reading-tests comparable to the child's

placement in school would show a passable result, but an almost complete blocking when new words were encountered. Thus one girl of thirteen read *architectural* without hesitation but was completely stampeded by *archaeological* although she knew the word by ear and read *logical* instantly when the first half of the word was covered up and then read the whole word with ease. This child has advanced in grade by dint of extra work, but her schooling has failed so far to give her the reading-tools that make fluency possible and that would permit her to increase her reading-vocabulary outside of school drill even to a degree equivalent to the word-meanings which she has stored by auditory implantation. Other facts in her performance and in that of similar cases lead me to believe that these children have suffered from a distinct reading-disability which has been partially corrected but not sufficiently so to make reading a useful accomplishment to them. The influence of slow and insecure reading on all other academic studies need scarcely be elaborated. One child tells me for example, "I can do my arithmetic if I understand the problem and I can understand it if the teacher reads it to me, but it's lots harder if I have to read it myself." These cases show a very much better auditory than visual memory and have often in the past been listed in the psychological literature as cases with predominant auditory-imagery or even as cases with defective visual-imagery. Such characterizations are, however, merely descriptive of the observed symptoms and all too often bear the implication of an inherent constitution which may block hope of remedy or at best suggests the use of the more facile path for training rather than a corrective frontal attack on the weaker one.

The conception of this whole group of retarded readers here presented, resting as it does on a physiological basis, offers a much more constructive approach to training than do its predecessors, that of brain disease, brain defect, or even that of an inherent psychological type. The errors which such children make in a test-situation not only will serve to determine whether this factor is the stumbling block in their reading, but will indicate the relative severity of the disability and give excellent clues to special methods of retraining. The tes of such an hypothesis lies largely in its applica tion and a fair number of retraining experi ments have now been carried out to the poin where I think we can say with fair security tha this disability can be very largely overcome whe it is recognized at an early period and prope training measures are immediately institute and consistently carried out. Such retraining for example, resulted in a full year's advance i reading after eight weeks of special work in group of children who had fallen behind on a average of over two years in reading while i the regular schools. The giving of an adequat skill in reading to the older cases is still in a experimental stage. I am undertaking th direction of a retraining program in two suc cases, but too recently to estimate the result which may accrue.

One factor which lends its aid to the proces of training is the earnest cooperation an willingness of most of these children as soon a they realize that they are no longer under sus picion of being "dumb-bells" or of not work ing. This is easy to understand. The reading disability does not correlate with intelligence,— our cases are found to cover practically the en tire range of intelligence as usually measure When a child of average or even superior min finds himself able to keep up with his class i arithmetic and to compete successfully in socia relations with his playmates, but sees most o his fellow pupils, including some who ar obviously more stupid than himself, makin progress in reading while he is failing, an where, since the obstacle which has blocked hi in this particular task is not understood, he i exposed to criticism, punishment and pressur from parent and teacher and the characteristi cally brutal frankness of other children, th effect on his emotional life is apt to be far reaching. From these emotional stresses w have seen the development of several reactio patterns. Some children become apathetic an indifferent to school. Others build a marke feeling of inferiority, while a few develo an antagonism toward their teachers and no infrequently become disciplinary problems. Th emotional load seems to be particularly trouble some when a younger brother or sister is makin

more rapid progress. Thus one nine-year-old boy who was entering the third grade in school but who was almost two years retarded in reading, showed very little evidence of strain until his six-year-old brother entered school and began to make headway in reading and then the strain began to be apparent. When such a child, who has been accused of inattention, laziness or stupidity, to explain his slowness, is told that there is a real reason for his delay and that he can probably learn to read as well as the others the response is such as to be very illuminative of the deep-seated feeling which his troubles have engendered. His attitude frequently changes at once and his hearty cooperation in the work is almost immediately forthcoming. Not infrequently the relief of the parents is also quite revealing.

There are many other implications of interest in this approach to educational difficulties by way of our knowledge of brain-physiology and brain-pathology. My choice of the term "impediment" in the title of this review was for the double purpose of implying something of less severity than a true defect and at the same time of relating this condition to certain speech disturbances. We now have reason to believe that many cases of stuttering rest on a different but comparable physiological confusion and in certain of these cases also our results in retraining are very promising. In spelling also many interesting data are accumulating. Where a child has a striking reading-disability, spelling also suffers and improvement in spelling results incidentally with reading-training, but in some children a failure of harmonious interplay between visual and auditory material as evinced in faulty spelling seems to exist more or less independently of difficulty in reading. Thus one small boy read aloud two pages of a story book for me with only three rather insignificant errors, yet made twenty-eight bad errors in spelling orally words selected from the material which he had just read. (Among these were such bizarre mistakes as *qulkey* for *quickly*, *enmuouse* for *enormous* and *trounth* for *through*). Retraining in this type of handicap would also seem to offer great promise although our work in that direction has not as yet been carried far enough to be conclusive.

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THE "SIGHT READING" METHOD OF TEACHING READING, AS A SOURCE OF READING DISABILITY

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I feel some trepidation in offering criticism in a field somewhat outside of that of my own endeavor but a very considerable part of my attention for the past four years has been given to the study of reading disability from the standpoint of cerebral physiology. This work has now extended over a comparatively large series of cases from many different schools and both the theory which has directed this work and the observations garnered therefrom seem to bear with sufficient directness on certain teaching methods in reading to warrant critical suggestions which otherwise might be considered overbold.

I wish to emphasize at the beginning that the strictures which I have to offer here do not apply to the use of the sight method of teaching reading as a whole but only to its effect on a restricted group of children for whom, as I think we can show, this technique is not only not adapted but often proves an actual obstacle to reading progress, and moreover I believe that this group is one of considerable educational importance both because of its size and because here faulty teaching methods may not only prevent the acquisition of academic education by children of average capacity but may also give rise to far reaching damage to their emotional life.

The sight reading method (or "look and say" of the English) has been credited with giving much faster progress in the acquisition of reading facility than its precursors and this statement I will not challenge if the measure of accomplishment be the *average* progress of a group or class. Average progress of large numerical units, however, makes no allowance for the study of effect in individuals, particularly if certain of them deviate to some degree from the others in their methods of acquisition and therefore in their teaching requirements. To the mental hygienist whose interest is focussed on the individual and his problems rather than on group progress the results as determined by average accomplishment are of little value whereas the effect of a given method on the individual child is all important.

Outstanding cases of so-called "congenital word blindness"—a complete inability to learn to read—have been recognized and studied for a number of years at first chiefly by physicians. It has also been

recognized by teachers and psychologists that there is a large group of children who have a much greater difficulty in getting started in reading than would be expected from their ability in arithmetic, from their ease in auditory acquisition and from their general alertness. In the past there has been a tendency, at least among medical men, and to a considerable degree among psychologists as well to exclude the minor cases of slow learning in reading from the category of congenital word blindness. This largely derives from the work of Hinshelwood[1] who made the first extensive study of these cases following the pioneer work of Kerr[2] and Morgan.[3] Hinshelwood's statement in this is " . . . the rapidity and ease with which children learn to read by sight vary a great deal. No doubt it is a comparatively common thing to find some who lag considerably behind their fellows, because of their slowness and difficulty in acquiring their visual word memories, but I regard these slight defects as only physiological variations and not to be regarded as pathological conditions. It becomes a source of confusion to apply to such cases as has been done of late the term of 'congenital word blindness' which should be reserved for the really grave degrees of this defect which manifestly are the result of a pathological condition of the visual memory center and which have proved refractory to all ordinary methods of school instruction." Unfortunately, Hinchelwood's criterion is a double one, neither part of which can be looked upon as of sufficient diagnostic accuracy to establish a clear cut entity. Not only has no pathological condition of the visual memory center yet been substantiated in such cases but there are certain neurological and clinical data which suggest that no such condition exists. Again, the "ordinary methods of school instruction" does not prove to be an accurate measure. Such methods vary widely and our own figures indicate that the number of children who show a significant handicap in reading is to some degrees related to the teaching method in use. Bachmann[4] has called attention to the looseness of the concept of congenital word blindness and related to this the striking variation in the frequence of such cases as recorded by various authors. Without some fairly clear objective symptoms on which to establish the entity, the choice of cases to be included naturally rests on the judgment of the examiner as to the severity of the disability. My own initial work[5] in this field led to a firm conviction that we were dealing here, not with two separate groups—a physiological and a pathological —but that those children who were *specifically* retarded in reading (thus excluding cases of general mental defect) formed a graded series extend-

ing from the normal to the extreme and that they showed consistent characteristic performance which not only would serve for diagnosis but which also was highly suggestive of the reason for their lack of progress and which gave excellent cues to methods for retraining. I was convinced not only that the specific reading disability formed an entity of much greater numerical importance than had been recognized before but that it was (even in the extreme cases) an obstacle of a physiological nature rather than a pathological condition and that therefore adequate special methods of teaching should correct it.

I can not here go fully into the details of the anatomical background for our present theory of this disability but some presentation is necessary in order to illustrate the basis for the criticism of teaching method which is here offered.

Only a small portion of the retina of the eye is used in acquisition of reading. This is the focus of central vision or the *macula lutea*, so called because it is seen as a yellow spot in ophthalmoscopic examinations. The rest of the retina receives only general and less detailed impressions coming from outside the rather small area to which we are directing our attention. This point is noteworthy because the nervous connections of these two divisions of the retina are quite unlike. The peripheral retina or outer zone has connections with only one-half of the brain (there are some complexities here but these need not concern us). The *macula lutea*, however, which receives impressions with greatest detail and which is hence used exclusively in learning to read, has a double connection with the brain. The nerve fibers arising here divide and one-half of those starting from each macula goes to the visual area of the hemisphere of the brain of the same side and the other half to the corresponding area of the opposite hemisphere. Thus impressions received by either eye, or by both eyes, are relayed simultaneously to both hemispheres of the brain. This double implantation does not give us a double sensation in consciousness, however, as a touch on both thumbs would do. The simultaneous activity of both areas results in our seeing but a single image. The visual sensation, however, is not a unitary function. There is apparently need for the simultaneous or additive activity of several parts of the visual cerebral mechanisms to complete the linkage of a printed symbol with its meaning and the steps in this process are shown in relief by differential losses such as are seen when certain parts of the back of the brain are destroyed by disease. When all of that part of the brain which has to do with vision is destroyed the individual becomes totally blind.

The eyes, however, are not damaged and they can still be moved and they will turn toward a sudden sound and the pupils will respond by closing and opening to increase and decrease of the amount of light which strikes them. This condition is known as cortical blindness, to differentiate it from blindness due to disease of the eyes or optic nerves. We may, however, see things surrounding us with sufficient clarity to avoid colliding with them, that is to guide our general body movements but without being able to appreciate the meaning of things which we see. This was first demonstrated by Munk in dogs in which much of this part of the brain had been removed. They were able to avoid collisions but did not recognize their master or even food by sight alone, and did not cringe from a whip. To this condition Munk gave the name of mindblindness and its parallel has since frequently been recorded in cases of disease of the human brain. Apparently at the first level the visual area of the brain serves as a very accurate guide to motion and it probably also furnishes the element of awareness of the external origin of a sensation (as contrasted to a memory). In psychological terms it furnishes the pure perceptual element to sensation but simultaneous or additive activity in other higher level visual areas are requisite to attach meaning and again we know that this is not accomplished in one step. If destruction of brain tissue happens in a certain area there results a condition in which the patient not only can see correctly but can also understand the meaning of objects seen, but in which the ability to read the printed or written word is entirely lost. That vision in the ordinary sense is normal, is shown by the fact that such a patient can copy printed material but cannot read either the original or his copy. Thus we see from these differential losses that the process of linking a printed word to its meaning passes through at least three stages of elaboration in the brain before it is completed.

There are differences, however, in the brain destruction necessary to produce losses at these different elaborative levels. Destruction in one hemisphere only is not sufficient to produce either cortical blindness or mindblindness. At these first two levels of elaboration, that is in perception and recognition of the meaning of objects, apparently destruction must involve the areas subserving these functions in both hemispheres before their loss results. The two hemispheres are apparently of equal importance here as it apparently makes no difference which side is affected; *i.e.*, either hemisphere is alone adequate for these functions. Exception must be taken to these statements in the case of peripheral vision but, as noted before, this is not of interest to

us here since central vision is used exclusively in learning to read. When we come to the third plane of elaboration, the situation is strikingly different, this is the level at which the written or printed symbol is linked with its meaning and hence it is variously described as the associative, concept, or symbolic level. Here not only is damage to one hemisphere sufficient to destroy function but it makes a difference which hemisphere is affected. If the hemisphere which is known as the dominant happens to suffer, a complete loss of this function results and the patient becomes word blind. If, on the other hand, the damage occurs in the other hemisphere—the non-dominant—nothing apparently happens. So entirely without result is a destruction here that this area of the brain takes its place with certain others among those which the surgeons called the "silent areas" of the brain. Obviously, the visual records implanted in both halves of the brain are not requisite for reading. This situation also exists in the field of understanding of the spoken word, and of speech and of writing. In all four of these functions destruction in the dominant hemisphere in the so-called language zone is meaningful while destruction in exactly similar parts of the opposite hemisphere is meaningless.

Thus we learn to understand, to read, to speak, and to write words from sensory records or engrams of one hemisphere only. This fact is so striking that we have been prone to overlook what must happen in the inactive side. We believe today that the completed growth and development of nerve cells is largely a result of stimulation. If cells do not receive stimuli they do not reach their full development. The two sides of the brain do not show much, if any, difference in size or complexity and certainly no such difference as we see in function as outlined above. To account for equality of growth we must accept equality of stimulation—equal nervous irradiation of the two sides—and if they are equally irradiated, records must be left behind in each; *i.e.*, engrams must be formed in the non-dominant as well as in the dominant hemisphere. To account then for the difference in effect of damage in the two sides we must assume that the engrams of one side become the controlling pattern through establishment of a physiological habit of use of that set and that the other set of recorded engrams is latent or elided. Variations in the completeness of this physiological selection, *i.e.*, failure of elision of the non-dominant engrams, forms the kernel of my conception of the reading disability. Such a theory conforms nicely to our observations that these cases are not to be divided into two categories, that is, cases of word blindness and cases

of slow acquisition of reading, but that they form a series graded in severity according to the degree of confusion which exists in choice of engrams and it also offers an explanation of certain errors and peculiarities which characterize their performance.

The two halves of the body are strictly antitropic, that is, reversed or mirrored copies of each other. The muscles and joints of the right and left hand, for example, are alike but reversed in arrangement. This is also true of the groups of nerve cells in the spinal cord which control the simpler motor responses (spinal reflexes) and also of the cells in the brain which combine or integrate these simpler spinal units into more complex acts. The movements of the left hand, therefore, which are the exact counterpart of the right will give a mirrored result. Thus, the movements of sinistrad (mirror) writing with the left hand are exactly comparable to those of dextrad writing with the right hand and it seems therefore highly probable that the engrams which are stored in the silent areas of the non-dominant hemisphere are opposite in sign, *i.e.*, mirrored copies, of those in the dominant. If then these opposite engrams are not elided through establishment of consistent selection from one hemisphere we would expect them to evince themselves by errors or confusion in direction and orientation and this is exactly what we find in cases of delayed reading.

This description is really "putting the cart before the horse" as our observations of tendency to reversals came first and the theory developed therefrom but this method of presentation has been adopted for the sake of clarity. Many workers with word blind children have noted their tendency to reversals but none, so far as I am aware, have offered an adequate explanation of it.

My original studies in a small group of cases convinced me that there were certain "symptoms" in reading disability which seemed to characterize the whole group and these were confusions between lower case *b* and *d* and between *p* and *q*; uncertainty in reading short pallindromic words like *was* and *saw*, *not* and *ton*, and *on* and *no;* a tendency to reverse parts of words or whole syllables as when *gray* is read as *gary*, *tarnish* as *tarshin* and *tomorrow* as *tworrom;* a greater facility than usual in reading from the mirror, and frequently a facility in producing mirror writing. These observations have been adequately supported in an extended study of a much larger group of cases. Many other types of errors are to be found in the performance of retarded readers but they appear to me to be secondary effects due to the failure of association which has resulted from the obstacle presented by confusion

in direction. The relation of the cardinal symptoms to the theory as above outlined is obvious and I think has direct bearing on the teaching method. Visual presentation will, hypothetically at least, result in the implantation of paired engrams and certain other factors must determine which of these is selected for associative linkage. What these factors are as a whole, we can not consider here although it may be well to suggest that heredity probably plays a part in the establishment of dominance here comparable to that which it plays in stuttering and in left-handedness. Undoubtedly training influences may be brought to bear on this process of choice, however, and from the theoretical standpoint the most promising of these should be that of kinæsthetic training by tracing or writing while reading and sounding and by following the letters with the finger (a method under taboo today) to insure consistent direction of reading during phonetic synthesis of the word or syllable.

Under a grant from the Rockefeller Foundation, an extended field study was carried out in 1926–27 in Iowa by the organization, as a part of the research work of the State Psychopathic Hospital, of a Mobile Mental Hygiene Unit to visit schools in various communities and a Laboratory Unit to study selected cases more intensively. Fuller reports of these studies are to appear elsewhere but certain observations may be quoted here. In my original group of reading disability cases, I was surprised at the large proportion of these children encountered. Fifteen out of one hundred twenty-five children sent by their teachers to our experimental field clinic for a variety of problems[6] seemed to me to show evidence of this trouble. In our extended work we have found in every community visited no less than two per cent of the total school population to be retarded readers showing this characteristic picture. Our studies were not carried out as a survey and hence these figures probably fall far below the actual numbers. There was however a difference in the numbers of cases encountered in certain communities which seemed to bear directly on the subjects here considered. Of two communities of about the same constituent population, in one we found about two per cent of the school population to be retarded in reading to a significant degree and to show symptomatic evidence of the specific disability, while in the second we found more then double this percentage. In the community with the lesser number of cases, sight reading methods were employed but when children did not progress by this method they were also given help by the phonetic method. In the town with the larger number, no child

was given any other type of reading training until he or she had learned ninety words by sight.

Aside then from theoretical considerations, this strongly suggests that the sight method not only will not eradicate a reading disability of this type but may actually produce a number of cases. Moreover, our retraining experiments[7] seem to indicate clearly that such children can be trained to read properly with adequate special methods devised to eradicate the confusion in direction and in orientation and this has also been borne out by the remedial efforts of other workers.

Our studies of children with reading disabilities has also brought to light certain other aspects of the problem which are of educational importance but which can not be elaborated here. Among these were notably the effect of this unrecognized disability, upon the personality and behavior of the child. Many children were referred to our clinics by their teachers in the belief that they were feeble-minded, others exhibited conduct disorders and undesirable personality reactions which upon analysis appeared to be entirely secondary to the reading defect and which improved markedly when special training was instituted to overcome the reading disability.

In brief, while "sight reading" may give greater progress when measured by the average of a group, it may also prove a serious obstacle to educable children who happen to deviate from the average in the case of establishment of a clear cut unilateral brain habit. These physiological deviates form a graded group extending in severity from the normal to extreme cases (congenital word blindness). They can be detected by appropriate examinations and trained to overcome their handicap by specific methods of teaching. While the number of children who suffer from such a severe grade of the disability as to be practically uneducable by ordinary methods is quite small, the number in whom the disability exists to a sufficient degree to be a serious handicap to school performance and to wholesome personality development probably is of real numerical importance and moreover there seems to be reason to believe that even those who make a spontaneous adjustment without special training, and thus learn to read, may never gain a facility in this accomplishment commensurate with their ability in other lines.

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THE NEUROLOGIC BASIS OF ELEMENTARY EDUCATION *

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Education in the broader sense is to be looked on as the whole of the process of training a child, beginning with earliest infancy, and thus including the extremely important period of pre-school training as well as academic education in its ordinary usage. Before a child enters school he has acquired a large storage of word meanings which have been implanted by way of the auditory path and which serve him as models for speech. He has thus already learned to use the third cerebral level of elaboration by way of the auditory mechanisms, but in the visual field he has not progressed beyond a use of the second elaborative level. He does make use of visual material controlling movement, and use of visually acquired objective data and associations have been formed between objects which he has seen and their names, thus linking the second visual level with the third auditory, but there has not as yet been any training for association of a symbol with its corresponding sound (letter) or of the association of a series of such symbols with the series of sounds forming a word which constitutes reading. One may thus look on the task of early academic education as chiefly the addition of the visual element to the auditory training which has already been begun at the third level.

The evidence of the existence of three progressive steps in cerebral elaboration of sensory material is to be derived from the study of acquired neurologic disturbances resultant on brain damage, such as cortical blindness, mind blindness and word blindness, and is also reinforced by studies of failure of acquisition of the third level function. This source of illuminative material stands out clearly in cases of strephosymbolia. These children have a good visuomanual association and are hence often dextrous in the use of their hands; they may also make good use of pictorial material, but fail entirely in ability to understand the meaning of words from printed symbols. In one case which I have already reported,[1] a boy, aged 17, with good manual control, showed unusually good use of pictorial data. He gave a rating by the Healy pictorial completion test that ranked him with the highest 10 per cent of normal persons;

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* Read before the Fifty-Fourth Annual Meeting of the American Neurological Association, Washington, D. C., May, 1928.

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in spite of this evidence of good vision at the lower levels of elaboration he could read only with the ability of a child in the first grade. A similar difference between the availability of visual and auditory material at the third level shows strikingly in many cases of special spelling disability, certain writing defects and in certain stutterers whose handicap is more strikingly apparent in attempting to read aloud than when attempting propositional speech.

The neurologic background of elementary education seems to have been almost entirely overlooked in current educational circles. The methods employed in teaching today are apparently largely determined by the results of average accomplishment in large groups of children and do not seem to have taken cognizance of the fact that certain children with good intelligence may deviate from the average in their ways of learning, so that pedagogic methods which may advance the class as a whole much more rapidly may yet serve as an almost insuperable obstacle to children within that class. Since elementary education consists of the establishment of association (or, if one wishes, the conditioning of reflexes) at the third level of visual elaboration and aims at the free interplay of visual and auditory implantations in control of both speech and writing, it would seem that the neurologic background may offer invaluable aid for the selection of those children who differ from the average in learning requirements and may also suggest special methods for their education.

INTERACTION BETWEEN THE AUDITORY AND VISUAL SPHERES

A facile interaction between the auditory and visual spheres is obviously necessary for reading. The visually acquired material must form a quick and secure association with the word meaning which has previously been implanted by the auditory path in order that the meaning of the printed word may be understood. A failure of this prompt linking results in strephosymbolia. That the visual factor is also operative in spelling is obvious when one recalls that it is only by visual implantation that one is able to remember the silent letters in words. Again, as the child progresses in school, reading forms one of the main pathways by which new words are implanted. That such words are useful in speech will, I think, be immediately apparent to any one who can recall his own hesitant attempts at the pronunciation of the word which is simple to him in reading, but which he has never heard pronounced by another. Neither the visual nor the auditory path will suffice alone for the cultivation of a vocabulary as higher levels of the educational plane are reached, and I believe that both operate together in the control of both speech and writing, although the importance of either is apt to be dependent on the quality of the speech and on the type of implantation

which has preceded it. Thus Lincoln's vocabulary has been held as a striking example of the influence of early reading on later speech habits.

My studies to date of special difficulties in the field of arithmetic are by no means sufficient to form an opinion concerning the interplay between the visual and the auditory here, but the spatial element of the decimal system and the progressional element in addition, subtraction, multiplication and division would all seem to indicate the need of cooperation between the visual and the auditory in the acquisition of even the fundamentals of this subject.

There is one fundamental necessity for the easy establishment of an association or for an easy conditioning of reflexes. This is constancy of presentation of the stimuli to be so linked. When there is much variation either in form or in time of presentation the linking is loose or is not established. The effect of this, I think, is to be seen in normal children who have much more difficulty with those letters which have a varying sound value, such as the *s* and *k* sound of *c*, the hard and soft sounds of *g* and the various sounds of the vowels. In normal children one observes that errors in vowels are much more frequent than those of the consonant sounds which are associated with a single symbol, such as *t, f, l, n* and *b*. Children who are later to become secure readers, however, overcome this difficulty relatively quickly, but it remains to a noticeable degree in those children who later show specific elements of reading disability. Children suffering from strephosymbolia show a weak and insecure association between the symbol *a* and the sounds *ā, ă, ä,* and often confuse the short sounds of *ă, ĕ* and *ĭ*. Another factor which stands out with prominence in these children is the striking tendency to confuse *b* and *d* and *p* and *q*. Sometimes these pairs of letters are consistently interchanged so that *b* is always read as *d,* but much more often the *b* and *d* have an equivalent value. In one of my recent cases, *b* and *d* were so completely interchangeable that baby, bady, daby and dady all meant baby to the subject. There is here apparently a complete equivalence of either letter and its mirror counterpart. Sometimes, however, the children do not show this facility for substituting one letter for another, but when either letter is encountered they show bepuzzlement, and the same indecision as to what a letter means is found in connection with other letter symbols which cannot be confused by reversal. I think, therefore, that while the confusion between the symbol and its mirrored counterpart is easily demonstrable with *b, d, p* and *q,* it probably also operates with other letters, resulting not in an interchange, but in a puzzling indecision.

Another interference with the normal processes of reading is seen in a striking tendency toward sinistrad progress within the word, which is one of the characteristic earmarks of strephosymbolia. Such

sinistrad reversals in direction are to be seen fairly frequently in practically all young children who are just starting to read, but those who acquire reading readily soon correct this tendency, while in those with a reading disability this continues to show itself in a variety of ways. Sometimes the whole word is read in reverse direction and *was* becomes *saw, on* becomes *no, not* becomes *ton,* etc. Again most of the word may be read correctly but a pair of letters is reversed as when gray is read gary, and target is read as targret, etc. Such words as calm and clam form almost insoluble puzzles for these children. Occasionally, children who have learned to read with considerable facility exhibit this reversing tendency strikingly in their attempts at oral or written spelling. No matter how one may look on the problem of cerebral localization, the major fact of antitropism of the two hemispheres remains, and the sinistrad progress is the natural expression of right hemispheric activity as dextrad progress is that of the left.

I think that one may now postulate from a study of the product of a large number of cases of reading disability and a somewhat smaller number of spelling defects that there are in all probability two factors operative here: (1) a tendency toward confusion in mnemonic recall between the original symbol and its antitrope, and (2) a tendency toward sinistrad progress within a word. The first of these, which is a static or orientation factor, I relate to an uncertainty of constant selection of the engram of one hemisphere. The second, which is a kinetic or progressional factor, is more closely related to the normal direction of progress for the left handed. I cannot as yet speak concerning the relative frequencies or the relative severity of these two factors, but apparently the children who suffer from the most severe handicap in reading exhibit both factors to a considerable degree, and it is possible that either of these alone may form a minor obstacle to reading progress but that a severe reading disability rests on their coexistence. There is also some suggestive evidence that these two factors may be separately inherited.

Many other types of errors in the reading attempts of these children are to be observed. They may make many errors in pronunciation of vowels. They often omit or add letters, words or parts of words. They frequently substitute complete words or repeat parts of them over and over again. All of these I now hold to be by-products of the fundamental difficulties in association resulting from the confusion and reversals which operate to prevent a facile association between the visual and auditory spheres, but do not in any measure show that such association is truly defective or that it cannot be adequately established by proper methods. This conception, as will be seen, immediately takes the reading problem out of the sphere of pathologic conditions and limits it to a physiologic failure and thus to a problem of adequate training.

Other things being equal, reinforcement of the associative process by means of a third sensory channel should secure a more adequate implantation and hence an easier association. With this general principle in mind, I have recommended the simultaneous tracing and sounding of a letter over its visual symbol. This differs to some degree from most of the previously used kinesthetic methods in that kinesthesis has been used chiefly for the purpose of aiding the visual implantation. Since, however, the aim is for greater facility of association between visual material and its auditory counterpart, it seems wise to link these together, using kinesthesis as the bond. The mechanics of this process, as carried out, is for the child to trace in script (or in the so-called manuscript writing) a written form, by which the visual is presented, and at the same time to sound the letter or word. Both the name of the letter and its phonetic equivalent should be thus linked to the visual symbol in order that the child may be taught to recall the name of the letter for purposes of oral spelling and the sound of the letter for purposes of constructive reading. The consistent motor drill of this kinesthetic method also aids markedly in written spelling, and has been used in a few cases for the correction of an isolated spelling defect.

The emotional variants, which are so frequently to be found in these children, I consider to be in large part a secondary result of the handicap rather than a causative factor. Granted an obstacle to reading progress which neither the teacher nor parent can understand, it is easy to see how a situation of extreme emotional tension for the child may arise. This emotional overloading is further fostered by the characteristically cruel remarks of other children. Another situation which frequently brings an obvious additional emotional stress is that which arises when a younger brother or sister is rapidly surpassing in reading capacity the child who is suffering from this handicap. From these emotional stresses, there may arise a variety of reactive patterns in the children, which are to be discussed elsewhere.[2] These reactions are frequently of prime importance from the standpoint of treatment, even though in our current envisagement they are not of etiologic rank. It is highly important that the child's cooperation and willingness to work be encouraged, and this can often be done only if his emotional antipathy toward a subject in which he has met with a serious obstacle is overcome.

I think it has been demonstrated, in most instances at least, that the physiologic variant which causes the reading disability can be overcome by proper training. As will be seen, this possibility of training holds a challenge to the view of inherent psychologic types. In the past one has been wont to look on certain persons as primarily visual or primarily

2. Orton and Sprague, to be published.

auditory in their mental processes, and the tendency has been to think of these as inherent patterns and to fit the training of the child for the use of that pathway which is the most facile. If, however, one can increase the facility of interchange between the visual and auditory, the logical point of attack in training should be not the most facile but rather that which shows the least facility. In the past, it has frequently been recommended that a child with a quick auditory memory, but with poor visual acquisition of words, should be prepared for a vocation in which most of his social intercourse will be by way of the auditory pathway. Today, I think, there is an open question whether training should not focus in such a child on the visual in order, so far as possible, to enrich the use of the lesser sphere and thus give him a much more rounded acquisitional capacity. The demonstration of the possibility of training in such cases also offers a strong challenge to the much looser psychologic concept of persons of the "nonverbal" type. This is particularly true of children who have an apparently quick mind, but show traces of a special disability both in reading and in the use of visually acquired material as a guide to speech. When one comes to consider such combinations of special disabilities, one is near to the problem of the feeble-minded. I feel sure today that when a reading disability or a speech difficulty (particularly of the type of developmental delay in speech) or a developmental apraxia exists in a child as an isolated defect, the condition is to be looked on as potentially correctable. When, however, two or more of these defects are present in the same child, the picture, both in general and by means of the results of mental tests, is characteristically that of feeblemindedness. How far training is possible in children showing two or more of these defects cannot as yet be answered, but in one case of this nature in which the child is now under retraining, definite progress has been made in a few weeks.

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THE RELATION OF THE SPECIAL EDUCATIONAL DISABILITIES TO FEEBLEMINDEDNESS

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Cases of limited intellectual failure were reported many years ago, notably in Germany, where they were looked upon as related to general mental defect and where they were classified under the term of partial imbeciles—"halb-idiote". Later an acute interest arose in England in one angle of this general problem, that of the selective reading disability. Rather naturally, it would seem, children who were not learning to read easily but who seemed bright enough in other respects were often referred to the opthamologists on the assumption that they were not seeing correctly and with the hope that correction of a visual defect might lead to better reading and it is thus that we find certain earlier studies reported by members of this medical specialty. Morgan called attention to the fact that the assumption of a mental defect here is not warranted since children who could not learn to read could be shown to be quite competent in other lines. Following Morgan's work, Hinshelwood studied intensively a considerable series of such cases and emphasized two points,—first, the rather frequent familial occurrence of inability to learn to read and second, the very close similarity between the clinical symptoms of patients with this failure in acquisition and of those in whom reading had been acquired and then lost through destructive disease of the brain. Since the brain disease cases had been described as acquired word blindness Hinshelwood offered, for the familial cases of reading disability, the term congenital word blindness. Acquired word blindness was at that time considered to be due to a destruction of the brain area intended for the storage of visual

word memories and this was identified as the left angular gyrus. Hinshelwood therefore inferred that the familial cases of difficult reading were probably suffering from an hereditary failure of development of this so-called area for word memories. So far as I am aware such a focal agenetic defect has never been demonstrated anatomically in a case of reading disability and moreover this hypothesis of Hinshelwood is not in harmony with current neurological views which hold that no such strict predestination of cortical areas can be assumed and that difficulties in the language function rest much more largely on disturbances of associative processes than on the loss of restricted memories such as those for words.

My own studies in these cases have led me to suggest that difficulty in the acquisition of reading in children who are obviously competent in other ways is due to the lack of establishment of exclusive control from one hemisphere of the brain, which we believe to be the normal mechanism of the language function. I can not here go into detail in discussion of the complex problems of the aphasias but it may suffice to say that from the mass of conflicting reports and opinions there emerges clearly the fact that damage to one side of the brain is sufficient to cause serious disturbances but only at the higher levels of psychological elaboration. To understand this viewpoint we must recognize that sensory experiences do not arrive in the brain full blown but that the visual stimuli, for example, must go through several steps of working over before the meaning of the printed word is understood. At present I believe these steps to be at least three and there is certain anatomical evidence which strongly supports this. The first step tells us of the external origin of the visual stimulus—in psychological terms it brings an awareness of externality and corresponds to the psychological use of the word sensation. Anatomically I think we can tentatively at least relate this to the activity of the "arrival platform" type of cortex which in vision is constituted by the area striata or calcarine cortex. A second elaboration adds to the

first a recognition of the meaning of objects. This differential step was first clearly seen in the ability of certain cases with acquired brain lesions to make adequate use of objects although they might not be able to name them or to read their names and it shows up in striking relief in cases of the reading disability who are frequently apt with their hands, who can work well with objects and even with pictorial material but who are quite unable to understand the printed or written word. This process corresponds to the psychological concept of apperception, and, I believe results from the activity of the cortex immediately surrounding the arrival platform which in vision is the area parastriata or common occipital cortex. The third step we believe to be largely an associative process whereby materials from various lower sensory areas are brought into cooperative interplay and it is at this level that the various language functions are resident and here also enters for the first time the striking disparity in functional control of the two brain hemispheres. Psychologically this is the level of the concept and of the symbol. Anatomically it is believed to occupy by far the largest part of the human cortex—the two great association zones which form the distinguishing mark of man's brain as contrasted to that of the highest animals.

In extended studies of the reading disability I have pointed out that the mistakes which children make in their attempts at words are to be looked upon as symptoms and that analysis of these will give us information as to why they do not learn to read. In this way it has been shown that certain characteristics are to be found in the attempts of the reading disability cases which differentiate them from the easy readers and which are also in numerical relation to the severity of the obstacle in a given child. The outstanding errors are an almost complete interchangeability of reversible symbols such as *b* and *d*, *p* and *q*, *on* and *no*, and *was* and *saw* and a tendency to read all or parts of words in sinistrad order. Apparently it is not merely that lower case *b* may be confused with lower case *d* but that they are to these children absolutely equivalent so that *dady*, *bady*, *daby*, and *baby* all bring the same impres-

sion and so that in recall a double *d* as in *rudder* may be written with one *d* and one *b*. An excellent example of this interchangeability was given to me by a small boy of seven who in attempting to write a *p* made two vertical strokes with three loops to the right and two to the left. His vote, so to speak, remains at 3 to 2 for the correct form. Reversals in sequence of symbols so that the normal dextrad order is disturbed is to be observed in reading, in oral spelling, and in writing. The tendency to read whole pallindromic words such as *saw* in the backward direction has already been mentioned but this progress to the left is also seen expressing itself in letter groups or in syllables. Two letters may be turned around as when *form* is read as *from, orphan* as *rophan,* or *gray* as *gary.* Sometimes the reversal is of one syllable as when *tarnish* is read as *ratnish* or *tarshin* or both syllables may be reversed as when *target* is read as *ratteg,* or both syllables may be read in the correct order but the syllabic sequence reversed as when *repast* is read as *astrep,* and finally only the first letter may be correctly placed and all the rest reversed as when *done* is read as *deno* and *tomorrow* as *tworrom.* Added to these mixed directions are to be seen the effects of other errors such as interchange of letters of somewhat similar forms, omissions of sounds and errors in pronunciation of vowel sounds. These further complicate the product but the analysis of such errors is interesting and illuminative. Thus by reversal of the whole word and interchange of *n* and *u, blind* becomes *build;* by reversal of the first syllable and assignment of the soft sound to the *g, target* becomes *ratchet;* by reversal of the whole word and omission of the last two letters *target* becomes *tegr* and since this brought no recognition, the child then offered *tiger;* by reversal of two letters, confusion between the short sounds of *a* and *e* and omission of the sound of *i, tarnish* becomes *trench.*

The children who show marked retardation in reading also show a greater facility in reading with a mirror than do normal readers and these facts, together with a number of others, have led to the hypothesis of the reading disability as probably dependent on a failure of constant selection of either the right or the left sensory record in the brain, i.e., failure of

establishment of unilateral cerebral dominance as the fundamental obstacle to reading progress.

To more clearly express this vision of a physiological concept of the reading disability and to contrast it with the former interpretation of Hinshelwood—i.e. that of a failure of development of a part of the brain which is essential for reading—I have offered the term Strephosymbolia to define the cases of retardation in the acquisition of reading skill in which there can be demonstrated a confusion between dextrad and sinistrad orientation of letters, a tendency toward sinistrad reading of all or parts of words and an unusual skill in mirror reading. Moreover, this interpretation avoids the difficulties which have been encountered in the past in drawing a line between the "pathological" cases of reading disability and those of lesser degree which have been classed as merely "physiological" cases of poor reading. No sharp dividing line could be drawn between these two groups and a study of a large series of cases of retardation in learning to read has shown that these reversal factors stand in numerical relation to the degree of the handicap and hence we may look upon Strephosymbolia as a clinical entity varying in degree of expression from the extreme cases to those in which a minor degree of retardation exists and thus including as variants in degree only both the "pathological" and "physiological" cases. It is to be noted here in passing that this condition must not be identified with handedness. A clear cut physiological preference for the left hemisphere results in right handedness and right eyedness, both of which would thus be looked upon as part of the expression of the left brainedness, and conversely a complete dominance by the right hemisphere would express itself in both left handedness and left eyedness and I think that we may safely assume that barring minor difficulties either would be entirely adequate. Consideration of the anatomical relations of the right and left hand will convince us that the natural way for a left handed child to write is not as we teach him but in mirror writing. Probably also mirror reading would conform better to his neurological patterns but we would expect such a child

to learn readily to reverse all responses just as the right handed child could be taught to read in the mirror or to write in the sinistrad direction. I see no reason to assume that right brainedness, if it be complete, will be in any way inferior to left brainedness and indeed many right brained individuals have been distinctly superior—notably Leonardo da Vinci who was left handed and whose private notations were written in the mirrored form. When however neither side acquires a complete control we would anticipate difficulty and it is this that I hold to underlie many of the special disabilities. I have emphasized this fact here because this problem has by so many been identified with that of left handedness and indeed my own work has been misquoted as identifying the two.

The fundamental source of this condition seems to rest on an hereditary basis. Apparently genetic factors determine the initial choice of the left or right hemisphere as the dominant one and where these factors are strong enough the unilateral dominance is complete and no difficulty ensues. Where however there is not a sufficiently strong tendency toward either side various expressions of confusion may result. It is thus that we see left handedness as a very common trait in those families in which the reading disability occurs although often the child suffering from this difficulty may be clearly right handed and right eyed.

There is accumulating evidence that a comparable failure in consistent unilateral control may express itself in other parts of the language function and it seems to play a leading role in many cases of delayed speech, in stuttering, and in isolated disabilities in spelling and in writing.

It may be noted that this view of the special disabilities resting on a physiological basis, that is a faulty brain habit, offers greatly enhanced hopes of improvement by special methods of retraining. Experiments in retraining have now been carried out in a considerable number of reading cases and in a lesser number of stutterers, poor spellers, and bad writers and the results of this work seem amply to support the physiological hypothesis.

Another point of great interest in the special disabilities is that they obviously do not correlate with the general intellectual level. In a study of an extended series of cases of the reading disability, children representing almost every intellectual level as estimated by the Stanford-Binet method have been encountered. When such a disability as that in learning to read stands in isolation in a given child it is fairly easy to determine, either by a large enough range of tests or by accurate observation of his adaptability in general that we are not dealing with a general mental retardation but rather with a special obstacle to acquiring a particular skill when taught by the ordinary methods. When, however, two or more such special disabilities coexist in a given child it is extremely difficult to determine whether we are confronted with multiple correctible difficulties or a general mental enfeeblement except by the crucial test of attempts at training by methods designed to meet his particular needs.

The modern viewpoint of the development of the mind is that a measure of the child's progress at any developmental level will serve to give a forecast of his ultimate capacities. This is inherent in the concept of the intelligence quotient and has also been stressed lately by Gesell on the basis of his observations of preschool children. This view rests on two assumptions both of which I think may be challenged—first, that of a unitary character of the intelligence and second, that of a uniform rate of its unfolding.

I think it may be said with regard to the first assumption that the more critical workers with intelligence testing methods are already cognizant of the fact that such tests do not measure intelligence in any true sense but merely show how the accomplishments of a given child compare with those of a large group of his same age but unfortunately this liberal view has not followed the testing method into the byways of its application and all too often the results of such tests are given with a feeling of finality which is far from warranted. In the reading disability cases there is also theoretical ground to challenge the results obtained by the most frequently used method of test—the Stanford-Binet. Two factors of interest here,

after allowance has been made for failures on tests in which reading is directly involved, are first, that the child by reason of his dislike for reading because of its difficulty for him has been exposed to much less of a verbal intake than have his companions who read easily and for pleasure and second, that the habit of failure in such tasks engendered by sad experiences in school work may readily operate to prevent proper effort on the test materials. Neither of these factors can be adequately evaluated as yet.

With regard to the second assumption, that of a uniform rate of unfolding or development of the mental faculties, I think that the special disabilities form a clear illustration that in certain instances at least this is not true. Pick and others have repeatedly emphasized the fact that delays in speech and in reading may occur in otherwise normal children, that complete development may occur in such cases, and that the delay does not necessarily imply a general mental defect.

The emotional status of the child suffering from one of the special disabilities is a point of prime importance both in estimating latent capacities and in the success of a retrainng program. The adjustments or compensations which must be made by a child faced with continued failure or great difficulty in reading may lead to a considerable variety of reaction patterns which must be taken into consideration. A marked feeling of inferiority leading to a lack of proper application to tasks which might prove readily soluble and a withdrawal from spontaneous effort in intellectual occupations is one of the commonest reaction types and when well established this is at times exceedingly hard to differentiate from a true lack of mental alertness. Often in such cases persistent active effort results from an explanation to the child of the nature of his obstacle and a certain measure of success resulting from this effort may lead to a striking change in attitude and accomplishment. No estimate of a given child's latent capacities can be just if based solely on his accomplishments or solely on his emotional status. The static mensuration methods of the older academic psychology largely dominate current psychometric practice while dynamic emotional concepts have absorbed the major interest of

modern psychiatry. The inseparable interweaving of capacities and the emotional reactions thereto seems to be particularly well shown in the special disabilities and I feel that no just separation can be made of problems of the intellect from problems of the emotional life or vice versa.

We have unfortunately in the field of feeblemindedness as yet no very accurate criterion of judgment as to the relative importance of structural and functional or organic and physiological factors. Excluding for the present the gross structural brain defects we are not in a position to say what constitutes the anatomical background of mental defect. Hammarberg made, it is true, a correlation with gross intellectual defects and structural failures of development of the brain but when we come to the lesser degrees of feeblemindedness we are frequently at a loss for an adequate structural explanation. Indeed the brains of some defectives will meet all of our present criteria of normality—in size, in weight, and in complexity of gyral pattern. We cannot say what factors of finer architecture may be revealed here by further study. The way is open for such an investigation but the work entailed will be enormous and pending its accomplishment may we not assume that some of these cases with the history of intellectual enfeeblement but with "normal looking" brains were in reality physiological variants in whom methods of training adapted to their specific ways of learning might have produced an adequate mind?

As a whole I feel that the occurrence of the special disabilities and their educability by proper methods demonstrate the importance of recognition of deviations from the usual patterns of learning and warn us of the need of a little more caution in accepting as final any present day methods of testing and of applying our attention to the challenging problem of devising means for the training of latent capacities.

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STUDIES IN STUTTERING

IV. STUDIES OF ACTION CURRENTS IN STUTTERERS*

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A number of authors have studied the action currents derived by application of electrodes over the bodies of muscles during voluntary contraction; but as far as we are aware, these studies, with one exception, have not dealt with a comparison of the action currents on the two sides of the body. The exception is the work of Golla.[1] By means of "two galvanometers which were constituted by two of the loops in an oscillograph," Golla recorded the action currents in the extensor muscles of each forearm when a left-handed subject was requested to dorsiflex both hands the moment he heard a sound signal. He reported records showing a well marked vibration coming from the extensors of the left forearm before any observable vibration appeared from the right. He further reported that when the subject raised the right hand only, the vibrations nevertheless appeared from the left arm before they did from the right; but that when the left hand was raised, a response did not follow from the right arm, although it was again recorded from the left.

We have been unable to learn whether or not this rather striking evidence of difference between the two hands in respect to the precedence of action currents was followed up by Golla; and it does not seem to have attracted the attention of other workers. To us, however, it appeared suggestive as a solution of one of the most confusing problems in the study of stutterers, that of determining the native handedness or natural physiologic bent after the person has been exposed to a variety of chance and determined factors of motor training. Students of the problem of handedness have devised many motor tests to determine the side with the greatest natural facility. In the case of young children and defective children who have not learned to write, such tests as rubbing, throwing, catching and winding string on a ball, and many

* The work here recorded forms part of a program of research in physiology of the brain carried out at the Iowa State Psychopathic Hospital under the direction of the senior author. Funds in support of this work were obtained from a grant from the Rockefeller Foundation and from the Graduate College of the State University of Iowa. While this study was under way the junior author was a Fellow of the National Research Council.

1. Golla, F. L.: The Objective Study of the Neuroses, Lancet **2**:115, 1921.

others have been devised. With those who know how to write, the hand used in this function is all too often regarded as an index of handedness. In spite of repeated advice to the contrary, it is still common practice among teachers to attempt to enforce the use of the right hand for writing in all left-handed children. In some children these attempts fail and in spite of pressure they use the left hand for writing as well as for other trained motor acts. In others, however, the pressure is sufficient to make them use the right hand for writing, and not infrequently these children, making a complete shift, outwardly at least, use the right hand by preference in every situation. Whether or not this shift in handedness is accompanied by any change in the physiologic lead from the cerebral hemispheres is a question much more complicated. Preference for the use of the right hand may, in certain cases, be purely an acquisition by training while dominance may remain in the right hemisphere. Such cases have led in the past to confusion in the literature on aphasias, and since in many hospital records the hand used in writing is the sole criterion of handedness, much of the literature dealing with the aphasias is open to question.

A number of writers have noted a relationship between stuttering and the enforced use of the right hand in writing in left-handed children. Claiborne,[2] especially, reported some interesting cases of naturally left-handed children who developed stuttering when they were forced to become right-handed. Nice [3] cited eight cases of delayed development of speech following a reversal of handedness. One of us [4] noted a rather high incidence of disturbance of speech in cases of disability in reading, and we have also found, in one person, stuttering associated with a striking disability in writing. These considerations focused our attention on the relationship of handedness (as an indicator of dominance) to stuttering; but, as outlined heretofore, we soon came to believe that the ordinary tests for handedness were of extremely small value, while Golla's observation gave hope of a method whereby certain pertinent information might be gained which would not be so masked by training as are the activities commonly appealed to, in tests.

Our anatomic hypothesis in explanation of stuttering is not so clear as that of strephosymbolia, or disability in reading, and its discussion may well be left for a later paper. In general, however, it is that lack of establishment of clearcut unilateral dominance might readily inter-

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2. Claiborne, J. H.: Stuttering Relieved by Reversal of Manual Dexterity with Remarks on the Subject of Symbol Amblyopia, New York M. J. **105**:577, 1917.

3. Nice, M. M.: Ambidexterity and Delayed Speech Development, Ped. Sem. **25**:141, 1918.

4. Orton, S. T.: "Wordblindness" in School Children, Arch. Neurol. & Psychiat. **14**:581 (Nov.) 1925.

fere with speech. The speech mechanism is an exceedingly complex integration of simpler reflex patterns, and this integration probably is not only cortical in origin but also entirely resident in the dominant hemisphere, under normal conditions. One of us [5] showed that striking dysintegration can be demonstrated in stuttering. This dysintegration appears as a lack of normal synchronism of various parts of the speech mechanism, as an antagonism between units of the breathing musculature, as tonic and clonic spasm of the muscles concerned, and as other such phenomena, and it seems conceivable that such dysintegration might result from confusion in dominant control.

Our present report deals with a study of the neuromuscular action currents of voluntary contractions in a group of normal speakers and a group of stutterers. In all instances the source of the action currents was the same, although our methods of amplifying and recording them passed through several experimental stages. The records made with the several different arrangements are combined in this report. Palmar flexion of all five fingers of both hands was chosen as the voluntary motion. The subject was told merely to "close both hands" at a given signal. German silver disks, 27 mm. in diameter, were used as electrodes. These were covered with canton flannel and kept moistened with a saturated solution of sodium chloride in distilled water. Two electrodes were used on each forearm. The proximal one of each pair was placed a certain distance from the median epicondyle of the humerus and the second one of each pair about 4 inches (10.16 cm.) peripherally from the first. An attempt was not made to find motor points; the electrodes were merely placed over the bodies of the flexor muscles without puncturing the skin and were held in place with fairly heavy rubber bands so that they would not be pressed much more heavily into the skin during the increase of girth of the contracting forearms.

All amplification [6] was obtained by means of three element vacuum tubes, and three methods of amplification were used: The first was the broadcast method, in which the currents derived from the forearm were amplified by a two stage transformer-coupled audiofrequency amplifier and then superimposed on a carrier wave set up by an oscillator tube. The modulated waves sent out by this minature broadcasting station were then received in a "pick up" coil of a standard eight-tube superheterodyne circuit. The second method was an impedance trans-

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5. Travis, L. E.: Dysintegration of the Breathing Movements During Stuttering, Arch. Neurol. & Psychiat. **18**:673 (Nov.) 1927; Photographic Studies of the Voice in Stuttering, ibid. **18**:998 and 1014 (Dec.) 1927.

6. The amplifiers were constructed for us by Theodore Hunter, a radio engineer and physicist, whose services were made available to us through the courtesy of the Graduate College of the State University of Iowa.

former circuit, which consisted of three tubes coupled as an impedance amplifier and two tubes as a transformer-coupled amplifier. An input transformer was used in this hook-up. The third method consisted of three stages of resistance-coupled amplification and two stages coupled as a transformer-amplifier. An input transformer was not used in this. The input was impressed through a condenser on the grid of the first tube.

The detailed wiring of these hook-ups need not be given here as apparently a fairly wide range of amplifier designs may be used satisfactorily.

As recording devices, we used, first, a two string galvanometer and, second, a pair of magnetic phoneloscopes. In the first, the shadows of the strings were photographed directly on standard width, superspeed moving-picture film; while in the second, beams of light focused on the mirrors of the phoneloscopes were reflected on the film. Our purpose was not to study wave forms or periodicities, but rather to compare the incidence of precedence in one arm with that in the other and to compare the relative amplitude of the action currents of simultaneous voluntary motion of the two arms; both methods of recording proved adequate for this purpose. A considerable number of observations by both methods were made in a few normal speakers and a few stutterers; and since, in respect to results, each method proved comparable with the other, we combined the observations in our tables, and did not indicate the records made with the galvanometer separately from those made with the phoneloscopes. When the effect of the action currents coming from the right arm was discernible on the record before that from the left, we designated this in our tables as a right lead and vice versa. In certain instances the incidence seemed simultaneous, and these we so described.

Figures 1, 2 and 3 show, respectively, a right, a left and a simultaneous lead. These are reproductions of photographs of actual film records made by the phoneloscope assembly. In all these, the beam of light from the right hand was somewhat less sharply focused on the film, and hence appears as a wider line. This was done for ease in differential recognition of the right and the left arm records. The time record was produced by connecting a sixty cycle alternating current through a step down transformer (110/24) and a 2 microfocal condenser to a third magnetic phoneloscope.

None of the persons whose numbers are entered in table 1 had observable defects of speech of any type, and they showed preferential choice for the right hand in carrying out all complex motor functions, including writing, and did not give a history of a shift from left to right in childhood. The table shows a striking predominance of right leads. As may be seen from the totals, the right leads for the group were more

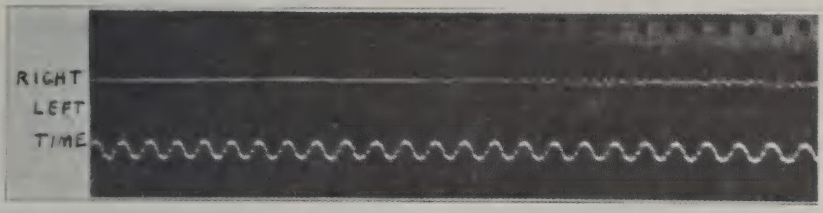

Fig. 1.—A photographic reproduction of a film record of the action currents from the right and the left forearms in a voluntary attempt to contract both simultaneously. The record was made by means of a phoneloscope assembly. The action current coming from the right arm is recorded as preceding that from the left.

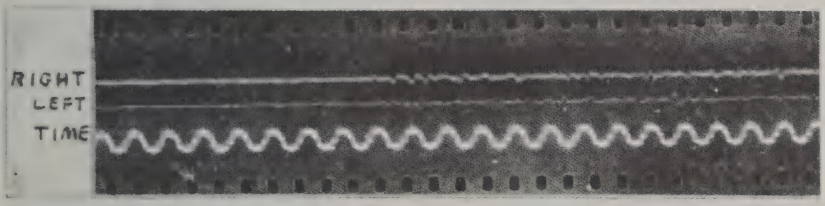

Fig. 2.—A photographic reproduction of a film recording the action currents from the left and the right forearms, the current from the left preceding that from the right.

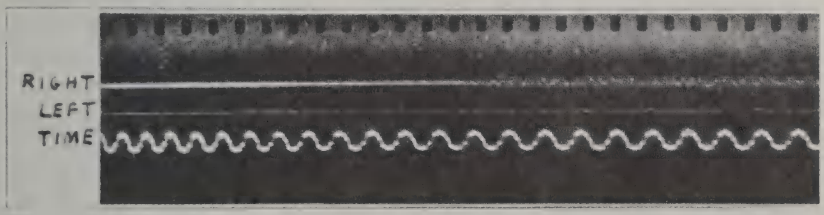

Fig. 3.—A photographic reproduction of a film recording the action currents from the left and the right forearms, the currents being recorded as simultaneous.

than nine times as frequent as the left leads, and more than eight times as frequent as the simultaneous leads. In only one person, no. 7, did the left leads exceed the right, and here the left were themselves exceeded by simultaneous leads. This person was an excellent player of tennis and handball; in both games he was able to use the right and the left hands with approximately equal facility. One other person, no. 9, showed almost as many leads in the left as in the right forearm. Although we suspected masked left-handedness in this case, we were unable to determine it definitely.

The table demonstrates that, in normal speakers who meet the ordinary criteria for right-handedness, when both hands are voluntarily closed simultaneously, the muscular action currents from the right forearm precede those from the left in the great majority of trials.

TABLE 1.—*The Incidence in Right-Handed, Normal Speakers of Right, Left and Simultaneous Leads for the Action Currents of Simultaneous Voluntary Contractions of Muscles of the Forearms*

Person Tested	Total Number of Trials	Right Lead	Left Lead	Simultaneous Leads
1	6	6	0	0
2	12	10	1	1
3	4	4	0	0
4	6	6	0	0
5	8	7	0	1
6	7	6	0	1
7	8	0	3	5
8	8	8	0	0
9	7	4	3	0
10	6	5	0	1
11	7	6	1	0
12	7	6	0	1
13	7	6	1	0
14	8	8	0	0
Totals	101	82	9	10
Per cent of total		81.18	8.91	9.81

All the stutterers whose records are shown in table 2 were to be ranked as right handed by the ordinary criteria, although four of them (nos. 2, 3, 6 and 13) gave a history of shift from the left hand in childhood. Only three, however, showed a greater number of right leads than left, nos. 4, 5 and 15, and in two of these the number of right leads was exceeded by the number of simultaneous leads. Another element of interest was the much higher relative number of simultaneous leads than in the normal speakers.

Table 2 shows that in a group of stutterers, although they were to be rated by the usual tests as right-handed, the time of incidence of the action currents in the two forearms gave results decisively different from those obtained by the same test in the right-handed normal speakers. In the normal speakers, the ratio of right leads to left was approximately as nine is to one; while, in the stutterers, it was approximately as one is to three. Again, in the normal speakers, the ratio of

right leads to simultaneous was approximately as eight is to one; while in the stutterers, it was about as one is to two.

The contrast between these observations is shown in table 3.

Results are not yet available on a large enough series of left-handed normal speakers to warrant statements concerning their action current pattern, although such records as we have seem to indicate that it is quite the reverse of that for the right-handed normal speakers. This set of controls was not considered requisite, since only one of all the stutterers

TABLE 2.—*The Incidence in Right-Handed Stutterers of Right, Left and Simultaneous Leads for the Action Currents of Simultaneous Voluntary Contractions of Muscles of the Forearms*

Person Tested	Total Number of Trials	Right Lead	Left Lead	Simultaneous Leads
1	5	0	3	2
2	4	1	2	1
3	2	0	0	2
4	9	4	0	5
5	5	4	1	0
6	7	0	7	0
7	5	0	4	1
8	5	2	3	0
9	4	1	1	2
10	6	0	1	5
11	2	0	1	1
12	21	1	17	3
13	10	1	4	5
14	6	1	1	4
15	5	2	0	3
16	18	1	13	4
17	8	1	7	0
Totals	122	19	65	38
Per cent of total		15.58	23.28	31.14

TABLE 3.—*Summary Contrasting Stutterers with Normal Speakers in Respect to the Incidence of Right, Left and Simultaneous Leads for the Action Currents of Simultaneous Voluntary Contractions of the Forearms*

Right-Handed Persons Tested	Number	Right Lead	Left Lead	Simultaneous Leads
Normal speakers	14	81.18%	8.91%	9.91%
Stutterers	17	15.58%	53.28%	31.14%

whom we examined showed a sufficiently distinct predilection for the use of the left hand to be considered left-handed.

Definite conclusions cannot be drawn from this material except the obvious one that the precedence pattern of the action currents in stutterers who use the right hand by preference in trained motor acts varies strikingly from that of normal speakers who have the same right-handed preference. We may, however, tentatively advance the suggestion that in many stutterers the motor facility as determined by training is out of harmony with the physiologic leads; and this envisagement fits nicely with the clinical observations of the relationship of stuttering to enforced shifts of handedness in writing in young children.

SUMMARY

When the currents of muscular action from both forearms are recorded during simultaneous voluntary contractions, they may appear simultaneously in the two arms, but in by far the greater number of trials the action currents from one arm precede those from the other by a short interval.

In records of right-handed normal speakers, the number of times that the action currents precede in the right arm far exceeds the precedence in the left, and also far exceeds the incidence of the simultaneous leads.

In "right-handed" stutterers, the greatest number of leads is in the left arm, and the number of simultaneous leads is much greater than in the normal speakers.

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FAMILIAL OCCURRENCE OF DISORDERS IN ACQUISITION OF LANGUAGE

By Samuel T. Orton
Psychopathologist

THAT the problem of a preferential use of either hand for complex purposeful acts is not based on any superiority of that arm and hand has long been recognized. Also it is readily demonstrable that there is no anatomical difference between the two sides at the lower motor (i.e. spinal cord) level, at all comparable in degree to the striking difference in skill between the two hands.[1] That this difference in motor facility rests on a differential use of the two cerebral hemispheres is emphasized by the intimate relationship of handedness to the loss of certain language functions in cases of brain damage by injury, tumor, hemorrhage, etc. I refer here to those cases which may be spoken of as the alpha-privative group of brain disorders—aphasia, alexia, agraphia and apraxia. While there is much contention among neurologists as to the exact interpretations to be applied here, one fact stands out in sharp relief and that is that a focus of destruction on one hemisphere of the brain is sufficient to cause any of this group of disorders providing it be in the so-called dominant or lead hemisphere and that similar damage may occur in the opposite or non-dominant hemisphere with no demonstrable symptoms resulting. As a clear cut example of this unilateral importance I may cite a case reported to me by a friend and colleague. This was that of a boy of fourteen who suffered a depressed fracture of the skull in the left occipital region. An operation was performed to remove the bone fragments and the underlying brain was found to be so badly softened that it could be removed by a suction apparatus and a sharply circumscribed defect was left 4 X 2 X 2 cm. After the operation his symptoms cleared up except that he had largely lost the capacity to read and write. As further evidence of this great preponderance in functional importance of one hemisphere may be mentioned the operation carried out as a palliative on several cases of inoperable brain tumor by an American brain surgeon of complete removal of the right hemisphere of the brain without losses in language or intelligence.

> *". . . . My current belief is that the major part of these special disabilities rests on the basis of a failure to establish a clear-cut unilateral brain control at the highest elaborative cerebral level and that they are due to an interplay between the hereditary patterns of the child and the methods employed in his training . . . . The child who is clearly left-handed . . . will not encounter much more difficulty in learning than the . . . . right-handed . . . ."*

Losses in the language function due to brain injury have attracted much interest from neurologists in the past and the literature bearing on them is enormous. A somewhat comparable symptomatology is to be seen in many children who, without any evidence of brain damage and with good intelligence, yet have great difficulty in learning in some one particular branch of language. These children constitute the group known as the special educational disabilities and their problem

[1]Orton, S. T. A physiological theory of the reading disability and stuttering in children. New England Jour. of Medicine. Nov. 1928, Vol. 199.

has largely occupied my time for several years. Following an intensive study of a few cases I[2] offered an explanation of the obstacle, of those whose difficulty was that of learning to read, based on the theory of a failure to establish a clear cut unilateral dominance leading to confusion in recall which interfered with reading acquisition. Since that time a large series of cases has been intensively studied amply supporting the symptomatology on which this theory was offered.[3] Studies in stuttering[4] were also undertaken to determine if possible the part played by cerebral dominance in this speech disorder. In cases of delayed development of speech, and of striking inability in writing and in spelling this view also offers much of interest and probable significance.

The specific reading disability we have shown to be characterized by confusions between *b* and *d* and *p* and *q*, by sinistrad progress in reading parts or all of words and by a facility in mirror reading. In many children it can be shown not only that *b* and *d* are confused but that they are entirely equivalent and the child may use either inter-changeably with the other so that he is quite unable to pick the proper form from such a series as *baby, bady, daby* and *dady* and so that in writing he frequently substitutes one for the other even in double letters as when *rudder* is written *rudber*. This confusion is held to rest on the fact that lower case *b* is practically the reversed or left hand pattern of lower case *d*. In this instance as in that of *p* and *q* the mirrored form is that of another letter and hence its miscalling shows what is happening. Additional evidence strongly suggests that this same reversed recall also plays a prominent part in slow learning with many other letters but does not identify itself to us so readily because the reversed form of most letters is not like that of any other. The second factor, that of sinistrad progression in reading a sequence of letters, shows itself clearly in the very common confusion between *was* and *saw, on* and *no* and other short pallindromes. It is not limited to these however and may be seen in reversals of paired letters as when *calm* is read as *clam* or *orphan* as *rophan;* and in reversals of syllables which may affect one syllable only of a word, as when *target* is read as *tarteg;* or it may affect both by reversal in direction, though assembled in proper order, as when *tarnish* is read as *ratshin;* or it may affect only the order of assembling as when *repast* is read as *astrep*. Occasionally the first letter alone may have its proper position and all the rest be reversed as when *done* is read as *deno* and *tomorrow* as *tworrom*. Many other errors such as those of vowel sounds, omissions of parts of words and misreading of consonants, enter into the picture and often lead to reading errors which form an entrancing challenge to understanding. If *blind* be read to the left and the *n* miscalled a *u*, it becomes *build*. Reading *card* backwards with a twist in the sequence of the *a* and *r* produces *bark*. When *target* is read from the left and the *at* dropped it becomes *tegr* and since this carried no meaning the child offered *tiger*. When the first syllable of *target* is reversed and the *g* given its soft sound the word becomes *ratchet*.

MIRROR READING

The third earmark of the retarded readers is their facility in mirror reading. Since they are slow readers both with and without the mirror their proficiency in reading the reversed form can not be directly compared with that of normal readers of the same age but if the ratio of time for reading in the ordinary form to reading in the mirror be taken it can be shown that those who have encountered a serious obstacle in learning to read, recognize the mirrored form proportionately much more quickly than do the good readers. Moreover the ratio is in fairly direct relation to the degree of their handicap and indeed severe cases sometimes read more rapidly with the mirror than they can without.

Because of the characteristic reversals of direction shown in these cases I have

[2]Orton, S. T. Wordblindness in Schoolchildren. Arch. Neurol. & Psychiat. Nov. 1925, Vol. 14.

[3]Monroe, Marion. Genetic Psychology Monographs. Oct. 1928.

[4]Studies in Stuttering. Orton, Travis et al. A series of Papers in Arch. Neurol. & Psych. 1927-28-29.

Wide World Photo

WHERE HANDEDNESS HABITS ARE LEARNED

Dr. Orton cites the case of a little boy of about the age of the younger of these children who stopped stuttering when his natural handedness tendency was allowed to develop.

offered the term strephosymbolia (twisted symbols) for the group and I believe that this disability rests largely if not entirely on the failure to acquire the physiological habit of leading exclusively from either cerebral hemisphere and that the confusions which exist and which block progress in reading skill are due to an inadequate elision of the engrams in the non-dominant side of the brain. This view, as will be seen, implies a physiological rather than a pathological basis for this disability which was the earlier view of Hinshelwood, who hypothecated a congenital defect of development of the area of the brain destined for the storage of word memories. The physiological view seems well supported by the striking improvement in these children when taught by methods properly adapted to their needs. Thus one of my cases, who had learned only a very few two- and three-letter words during three years in a high grade private school, gained four years of reading skill during one year of special retraining.

Attention has lately been directed to the comparative frequence of left-eyedness in the reading disability cases. By eyedness we mean a preferential choice of one or the other eye in sighting at a distance. This can be easily determined and some writers have held it to be a causative factor. It is of unquestioned frequence but in my own series of cases I have seen both right-eyed and left-eyed children and some who were amphiocular and all of these patterns have been found in combination with both right- and left-handedness and with so-called ambidexterity and I am inclined to look upon it as merely one of the methods of expression of cerebral dominance and of no greater diagnostic value than several others.

Delay in learning to talk well beyond the usual age period for acquiring this function is not uncommon. This is often one of the first signs observed by the parents in a child who later shows a markedly defective mentality. It is occasionally seen in children who have suffered birth injuries and sometimes obviously rests on defective hearing, especially if this be of central origin. A special group of children has been recognized, however, who seem as bright as others of their age,

who hear easily and understand what is said to them readily but who are very slow in talking. When speech is acquired by those of this group it usually develops rapidly and it may not go through all of the developmental stages of the usual acquisition period. My own observations in this type of case are not very extensive but in those which I have seen there has been an obvious, equal delay in developing a preference for either the right or the left hand except in those activities where training has determined it.

In stuttering, a wide range of abnormal motor responses of the breathing, vocal and articulatory mechanisms has been recorded, and various drill methods to correct faulty breathing and faulty phonation have been devised on the assumption that these were the cause of the stuttering. Modern neurological knowledge, however, indicates that such faults are not resident in these lower functions but that they probably arise from faulty integrations or faulty syntheses of normal lower patterns and that the proper integration of such reflex patterns into the orderly sequence of the speech act is resident solely in the language zone of the brain and hence that it is here rather than in the control of breathing et al., that we must look for the origin of stuttering. This, together with recorded observations of the occurrence of stuttering when left-handed children were forced to write with the right hand and its disappearance when left-handed writing was permitted, led us to study this phase more closely. From the beginning of this work we were impressed with the great difficulty in determining the natural bent or physiological handedness of an individual after he had been exposed to various forms of training. Golla in England has recorded that when the action currents from both forearms were impressed on sensitive galvanometers and a left-handed patient was asked to close both hands simultaneously, the galvanometer connected with the left arm registered the action current effect first. Travis and I[5] applied this method to a series of stutterers and a series of normals by means of two multiple vacuum tube amplifiers and two magnetic phoneloscopes and found that the action current patterns of "right-handed" stutterers were strikingly different from those of right-handed normal speakers. In the normal speakers the action currents appeared first in the right arm in 81.18 per cent of the trials, first in the left arm in 8.91 per cent and simultaneously in 9.91 per cent. In the stutterers, all of whom were right-handed as determined by all ordinary tests, they appeared first in the right arm in only 15.58 per cent of the trials, first in the left in 53.28 and simultaneously in 31.14 per cent. Not infrequently in young stutterers who have not been exposed to much pressure in training for the use of either hand, a very striking parity in the skill on the two sides can be demonstrated. This I have met especially in those who have stuttered from the beginning of their speech efforts.

AN EXAMPLE

One girl of twelve who has always stuttered was able to write on the blackboard with both hands at the same time, with her eyes closed and in either direct or mirrored form and in all combinations of these, viz., direct with the left hand and mirrored with the right etc., and in all with a very close similarity of product. This child had always been left-handed and was being trained as such. The situation here is obviously different from that in those cases where speech is clear at first and the stuttering begins later. Sometimes this may be associated with quite early training of the child as in one of my cases, a boy of three, who had been stuttering only two weeks when I first saw him. On asking the parents about handedness the mother replied, "He is right-handed in everything" but the father thought he was about half and half. After a period of one week of close observation the parents returned with the story that the boy used his right hand in only three activities, eating, throwing a ball and digging in the sand and in all these he had been trained by his elders. In everything else he made use of his left hand, and in a cinematographic picture of him, feeding chickens at the age of two, he was seen to be holding the pan in his right hand and scattering the grain with

[5]Locus cit.

his left. The parents were advised to retrain him entirely as a left-hander and within two weeks his stuttering had stopped. More frequently the stuttering starts early in the school period and often it is associated with the mistraining either by design or through oversight of a naturally left-handed child.

Special disabilities in writing are not infrequently encountered. In some, as in certain stutterers, the problem seems to rest on the use of the wrong hand. One such case, a boy of eleven in the fifth grade of a very good private school, had made very poor progress in writing; he was also an exceedingly bad speller, stuttered a little and was looked upon as an extremely nervous child. When tested for his writing facility with both hands with pencil and paper the product was not strikingly different, but when tested at the blackboard with his eyes closed his left-handed writing was distinctly superior. Retraining was immediately begun and with one year's subsequent training his writing with the left hand was far ahead of the product of his right after five years of drill. In another of my cases, a medical student, writing with either hand in the dextrad or ordinary direction was next to impossible. He could write simple home letters and accustomed phrases so that they could be read but when attempting to write and think, as he put it, at the same time his efforts were scarcely decipherable. On examination, however, it was found that even without training he was able to write quite legibly and freely in the mirrored form. To make available to him this latent capacity we suggested the use of a sheet of carbon paper upside down under the sheet on which he was writing. When he then wrote in mirrored form on one side, the carbon paper copied it in reversed or dextrad form on the other and his product could therefore be easily read by turning over the sheet. Both the father and paternal uncle of this case also suffered from a striking writing disability.

Spelling errors are so common that difficulty in this regard is often considered as not of serious moment, but a true selective spelling disability may occur of such severity as to form a decisive handicap. In practically all cases of strephosymbolia as outlined above, there is a marked defect in spelling comparable usually both in degree of severity and in kinds of errors to the handicap in reading. In extreme cases the attempts at writing words may give a product which is wholly illegible. A striking example of this was offered by a sixteen year old boy who had reached the seventh grade in school but whose reading capacity was that of a first grade child. An excerpt from a school composition in American history describing the English campaign of 1777 read in part as follows:

I. Comter in 1777.

The Enlgand camele stosent in cane hosterson the their last scoune and honeter posterson and rososon and sean 1000 scouter then to pastore and the fosteron the secounter tall theen heuster and at dog befor mostir, etc.

ISOLATED

Marked defects in spelling, however, may also occur as an isolated disability in good readers. Many interesting errors show themselves here. Most frequent are those which are comparable to the errors in reading, confusions of *b* and *d*, and *p* and *q*, reversals in sequence, errors in vowels, omissions of letters, etc. One seven year old second grade boy, when asked to write the alphabet dodged the *b-d* pitfall by using a capital *B*. When he came to *d* he again used the capital and when asked to write the small letter he first produced a *b* which he then crossed out and wrote a *d*. In writing *p* to dictation he recorded beautiful evidence of his insecurity. He made two vertical strokes with three loops to the right and two to the left, thus leaving his guess at three to two in favor of the correct form. An eleven year old boy in writing both *way* and *by* started with the *y* first; in writing *baby* produced *bady* which was then corrected, and in writing *liberty* started *led*, saw the error and crossed it out, then wrote *lebatry* with the *r* and *t* reversed in position, again saw his error and crossed it out and wrote *lebarty* and made a final correction by writing an *e* over the *a*. Many other interesting misspellings are to be seen. The sound of *w* is often taught as that of *oo* so that the child is taught to pronounce *went* as though it were *ooent*. This has occasionally carried over

into spelling so that one boy writes *news* as *nwz* and another, *school* as *skwl*. One of the current methods of teaching reading also apparently plays a prominent part in some spelling errors. Certain children who have been taught by the "sight reading" method have only short words to represent certain sounds so that they do not know any symbol for the long *u* sound except *you* for example. This produces such spellings as *egyoucaytion* for education, *dockyoument* for document and *tacksaytion* for taxation. One boy read hostility as *hostlostily* and on question as to how he got this he replied, "I don't know *h-o-s-t*, but I do know *l-o-s-t* so I took the *l* off and put an *h* on". Apparently the *lost* was still reverberating when he reached the *l* in hostility. It would seem obvious that the training which this child has received in reading by word units rather than by letters or by syllables has provided him with exceedingly clumsy tools to accomplish the analysis of new words. The relationship of cerebral dominance to misspelling is not so clear as in certain other disabilities but the similarity of many errors with those of the reading disability is extremely suggestive here.

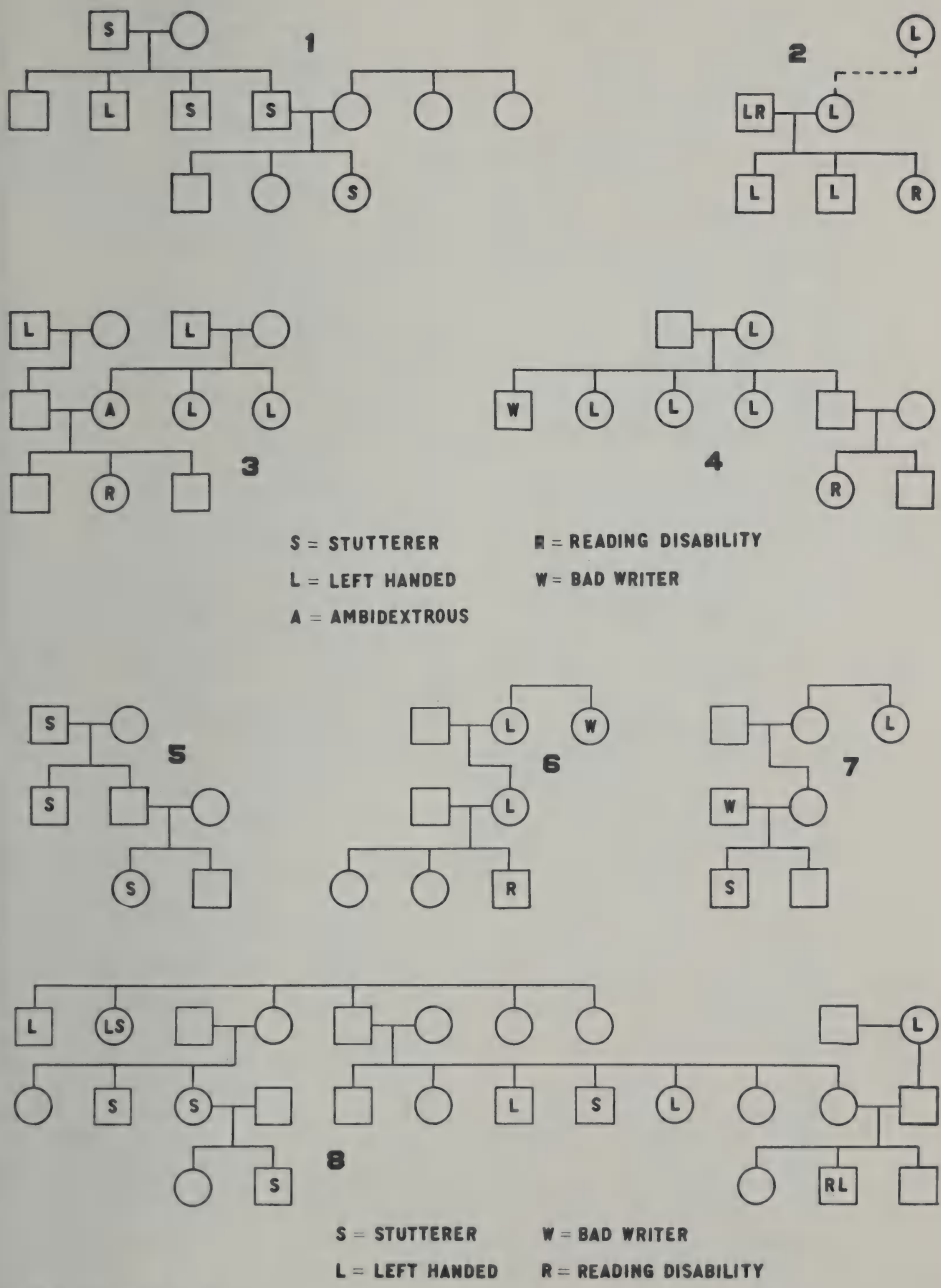
Cases of developmental apraxia have also been recorded in medical literature. I have found a history of unusual clumsiness and difficulty in learning trained movements to be of quite frequent occurrence in a number of cases who later encountered difficulty in speech and in reading and believe it to have significance in this regard. A comparable difficulty in copying movements of others, such for example as dance steps is occasionally seen in older children and in one I found that while direct mimicry of a movement pattern was difficult and clumsy yet imitation could be carried out with much greater grace and freedom when the pattern was seen in reverse before a large mirror.

My current belief is that the major part of these special disabilities rests on the basis of a failure to establish a clear cut unilateral brain control at the highest elaborative cerebral level and that they are due to an interplay between the hereditary patterns of the child and the methods employed in his training. Aside from the inconveniences impressed on a left-handed person by customs largely devised for the right-handed there seems to be no valid reason to consider one motor pattern as better than the other and I believe that the child who is clearly left-handed—i.e. right-brained—in everything, will not encounter much more difficulty in learning than the clearly right-handed. Between these two extremes however, there appears to be a group of considerable size in whose members variants in the establishment of unilateral control occur and these children encounter obstacles which can only be overcome by methods of teaching specifically adapted to their needs.

Left-handedness has formed a topic of considerable interest from the genetic standpoint and Hinshelwood and others have emphasized the familial occurrence of the reading disability. My own family studies have so far been rather cursory but even in this incomplete form I think they show an interesting interrelation between many of the special disabilities discussed above and I am therefore offering this as a suggestion that the genetic problem here is not simply that of left-handedness but the much more complicated one of cerebral dominance with its many forms of expression.

THE CHARTS

The charts appearing upon page 146 show the data available in my case records in eight families. In Family 1 the patient was a girl of eleven who had stuttered from her earliest efforts at speech. She was left-handed in most things but showed a noteworthy parity in writing simultaneously with both hands in either dextrad or sinistrad forms. Her father, one paternal uncle and her paternal grandfather stuttered. The uncle is said to have been "broken of left-handedness" and another uncle is left-handed. Family 2 is that of a small girl with an extreme case of reading disability. She is amphiocular,—that is she uses either eye interchangeably in sighting through a hole in a card. She has shown little preference for either hand but has learned to write with her right hand. She has two left-handed brothers. Her mother is left-handed. Her father started as left-handed, was shifted to the



By Courtesy of the Author

THE HEREDITY OF SPEECH DEFECTS

See text for explanation of symbols.

right, but went back again and now can do about equally well with either hand. He is a poor speller, a slow reader and has always encountered difficulty with language. Mathematics is easy for him. The mother's grandmother was also left-handed. Family 3 is that of another girl with a marked reading disability. She is considered right-handed and uses this hand by preference in writing and other trained movements but she is left-eyed. Her mother is "ambidextrous" and two paternal aunts and both grandfathers are left-handed.

Family 4 is that of another girl with a severe degree of reading disability. She is right-handed in writing and most other manual things but prefers to bounce a ball and throw with her left. She is right-eyed. Her three paternal aunts and her paternal grandmother are left-handed and a paternal uncle is an extremely bad writer and was very backward in school although he has since been very successful. Family 5 is that of a three year old girl who had just begun to stutter occasionally. She used her right hand in most trained acts but was also quite facile with the left. She was amphiocular and this was easily observable because of a crossing of the eyes which made it possible to see readily which was leading. Thus while working with a pencil part of the time the right eye was focussed on the task and the left turned in but part of the time this order was reversed. Her father is said to be right-handed in everything except throwing a ball. Her paternal uncle has stuttered badly from childhood and her paternal grandfather stutters slightly. Family 6 is that of a boy of nine with great trouble with reading. He is left-eyed. He uses the pencil in his right hand but his efforts are laborious and his product poor. In other things he also uses his right hand by preference. His mother is left-handed and had considerable difficulty in school. His maternal grandmother is left-handed and a maternal great-aunt is a "very poor writer". Family 7 is that of a sixteen year old boy who stutters rather badly. He uses his right hand by preference in writing, throwing, tennis, etc. He is left-eyed. His father is said to be an exceedingly poor writer,—to be very "nervous" when he tries to write and to restrict his efforts in this regard largely to the signing of his name. The boy's maternal great-aunt was left-handed. Family 8 is that of a nine year old left-handed boy with a rather severe reading disability. His left-handedness was recognized early and he has always been encouraged to use that hand. He is also left-eyed. As the chart shows, his paternal grandmother was left-handed and there is marked occurrence of both left-handedness and stuttering in his mother's family.

My records so far are obviously inadequate to serve as a basis for opinion regarding the nature of transmission of these variants. In one family, which is not charted here, speech disorders, represented by both delayed speech and stuttering, seem to have been passed by unaffected daughters to their sons but in others this is obviously not true. One fact of interest here is the numerical relation of the sexes in certain of these language disorders. Stuttering is recognized as much more frequent in boys than in girls although the proportions given vary considerably according to different authors. In an intensive study of a group of one hundred and seventy-five cases of the specific reading disability we found three and a half times as many boys as girls.

CONCLUSION

In closing I would like to repeat that in many children the determination of the native handedness is not easy and that the many rule-of-thumb tests are far from satisfactory, especially after the child has been exposed to either purposive or accidental training. In the study of the majority of cases of language disorders due to brain injury recorded in the medical literature this question has received rather scant attention and often the sole criterion for handedness is that of which hand was used in writing. With the widespread tendency of mothers to train their children to be right-handed and the equally wide demand by school teachers that every child be taught to write with his right hand if it can be done, it is obvious that many of our case records may be misleading in this regard and I believe that this must also be taken into account in the study of the genetics of left-handedness.

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CHAPTER XXI

SOME STUDIES IN THE LANGUAGE FUNCTION

SAMUEL T. ORTON, M.D.

AN INTEREST of many years standing in the problem of aphasia and the other syndromes that I have been accustomed to call the alpha-privative group (aphasia, agraphia, alexia, apraxia, et al.) has led during the recent past to an intensive study and, I believe, to a somewhat better understanding of the disorders and delays in the acquisition by children of the various fractions of the language faculty and to methods of treatment which are, in many instances at least, proving their efficacy.

In these disorders of acquisition we meet syndromes which very closely approximate the losses of a previously acquired language facility which follow lesions of the brain in the adult. The close symptomatic similarity between children who could not learn to read and cases of acquired alexia in adults led Hinshelwood to classify the former under the name "congenital word blindness." At the time of his studies, acquired alexia was considered to be due to a destruction of that particular cortical field which served as the "center for visual memory of words" and he made the assumption that in congenital word blindness there is a failure of development of the cortex destined to serve as the visual word center. I need not here go into the reasons which have altered our thinking from that of the strict predestined pigeon-holes of the cerebral localization of that day to our present somewhat more elastic views. It may suffice however to say that Hinshelwood's assumption in this particular seems no longer tenable. There is no precise evidence to support such a focal agenesis and much to suggest that, did it occur, adjacent brain areas would be competent to assume the function. Moreover there seems to be reasonable ground to assume a physiological disorder rather than an obligate structural defect in explanation of these cases. There remains however so instructive a similarity of symptoms between failures of acquisition and loss of language that I believe that no study of either can be considered complete without a comparable investigation of the other. The delays and failures in acquisition offer one great advan-

tage over the alpha-privative syndromes in the investigation of the normal physiological processes since they are often limited quite sharply to one fraction of the language faculty and hence bring out the failures in associative integration in bold relief in a way that will be encountered only in the rarest of cases of the alpha-privative group. On the other hand, they are not usually associated with disease processes which are apt to lead to death and thus do not supply opportunities for autopsy control of our clinical studies.

CEREBRAL DOMINANCE

The one outstanding peculiarity of the cerebral patterns underlying language in the adult is that of the much greater physiological importance of one hemisphere than of the other in this faculty. This is the phenomenon of unilateral cerebral dominance. Stated briefly, in the adult losses in the capacity to understand the spoken word, to reproduce it, to interpret the graphic word, or to reproduce it, may or may not occur following destructive lesions of certain brain areas, dependent on whether or not the master hemisphere is involved. The master hemisphere is usually indicated by the master hand but here many uncertainties appear because of the existence of many mixed patterns and because of the influence on handedness imposed by early training. Most notably does this last factor affect the hand used for writing, which is the commonly accepted criterion of the handedness pattern of an individual in hospital records.

In addition to the group of functions above outlined as constituting the language faculty, viz., understanding and reproducing both spoken and graphic words, certain other functions apparently are controlled from the master hemisphere. Here we may mention the conscious representation of the body image, of which Schilder has told us, and many of the more complex postural and motor patterns whose disturbance is seen in the apraxias.

The principle of unilateral physiological superiority in the adult brain can be held to be established however, only in these more intricate patterns of integration and obviously does not obtain at the projections levels. It is scarcely necessary to review for this volume the strict heterolateral and independent function of the two hemispheres in the hemianesthesias, the motor paralyses, or the hemianopsias. In macular vision we find a double implantation, both hemispheres being irradiated from each macula by virtue of the dichotomy of the fibers

from the ganglion cells of the retina underlying each macular area. In the auditory field our knowledge is much less precise. This function is generally thought to operate as a bilateral mechanism and hence to be comparable with macular vision. Certain recent observations made in my laboratory suggest tentatively, however, that the capacity to judge correctly the direction from which a sound has come may be a unilateral function while total acuity and especially that part which deals with the higher pitches of the speech range may require bilateral integrations. Should these as yet very sparse observations be confirmed by further studies they would form an exceedingly interesting analogue of the plan of organization of the peripheral and central retina. On the whole, the auditory functions seem to have been subjected to much less critical analysis than their importance would justify.

Between the projection levels, however, and those in which the physiological superiority of one hemisphere is generally accepted lies a sort of "No Man's Land" which receives relatively little attention in the literature of the aphasias although its disorders are frequently recognized when they exist as an isolated clinical picture. I refer here to the agnosias or disturbances of function of what may be called the second level of cerebral elaboration. The segregation of three distinct stages of elaboration of sensory material in the visual sphere is clearly indicated in our terminology by the three clinical concepts described as cortical blindness, mind blindness, and word blindness. Comparable terms for the auditory sense are found in cortical deafness, mind deafness, and word deafness. In the kinesthetic field the corresponding words for the first two are hemianesthesia and astereognosis. I know of no single word to represent the loss of the derivatives of this sensory field at the third level.

The second level of the kinesthetic function has taken a place in methods of examination and as a localizing index in studies of the aphasias but I feel that the corresponding stages of elaboration of the visual and auditory sensations have received far too little attention. Critical studies of the integrity of this level in these two functions are not only very rare in reports of the aphasias but even our testing methods are deficient in this respect. What series of aphasia tests, for example, aims at the investigation of the patient's retention of the normal capacity to differentiate between the multitude of meaningful sounds other than words?

Support for the existence of such a second level or intermediate stage of integrative complexity comes from many sources—anatomical, phylogenetic, and pathological—but perhaps it may be briefly illustrated by the contrast between visual agnosia and alexia (or between mind blindness and word blindness). The visual agnosic is not blind since avoidance reactions are intact although he interprets nothing of what he sees except its position. That this is not a more fundamental loss, i.e., a true dementia, is shown by the prompt recognition of the purpose and use of objects when examined by touch and kinesthesis. The alexic patient, on the other hand, shows an extensive visual familiarity with objects although unable to recognize the graphic characters which serve as their symbols.

Cases with the alpha-privative syndromes, however, rarely exhibit as clear-cut pictures as do those with defects in the acquisition of language in children. Indeed, the restriction of functional defect following a brain lesion to one fraction of the language faculty is so rare that one frequently finds the statement in the literature that there is no such condition as pure word blindness or pure word deafness. This is not so in the delays of acquisition. In uncomplicated cases of strephosymbolia (or the specific reading disability), for example, it is possible to show that there is active use of many visual patterns much more intricate than those of the avoidance reactions which we, by analogy with mind blindness, relate to the first level and yet the visual mechanism fails strikingly at the third or word level. Let me sketch here a composite picture of a case of this nature drawn from the experience gained in intensive studies of several hundred strephosymbolics.

A HYPOTHETICAL CASE

I have chosen a boy to represent this hypothetical patient since the reading disability is more than four times as common among boys as among girls. He is almost nine years of age and is just finishing his third year in school but is failing in all of his work except his arithmetic which he does well. His father is a college professor and his mother a college graduate and the home environment is conducive to an intellectual interest. Inquiry into the family history reveals several left-handed or "partly left-handed" individuals in immediate or collateral lines, among whom is the patient's brother who learned to read at an early age. The parents assert, however, that the patient himself has never shown any preference for the left hand and our observations of his common motor patterns as well as of his acquired skills and his eyedness all bespeak a clear dextrality. The history of his development gives no evidence of delay in sitting, creeping, walking or talking.

He has suffered no head injuries or very severe illnesses. He has learned easily by ear and his vocabulary is good for his age. Until he entered school he had been looked upon by his parents and also by less interested observers as a more than usually alert and intelligent boy. In school he did quite well in the first grade and his capacity to learn by ear and thus to keep in touch with the class room material through the recitations of others quite misled his second grade teacher as to the really serious nature of the difficulty he had encountered in learning to read. In the third grade, however, this became increasingly apparent and his parents were advised to take him to an oculist on the natural assumption that he was "not seeing his words correctly." He is quite a leader in athletics and very fond of manual arts of all sorts and the school reports a good natural aptitude in this direction. He has a frank and open personality and a cheerful disposition until the school subjects of reading, writing, and spelling are mentioned and then we see evidence of a strong emotional reaction and he remarks, "I guess I'm a dumb-bell 'cause I can't learn to read." Questions about arithmetic bring out no such feeling of discouragement.

When we examine him we find a lad who, in spite of his inability to read and the consequent penalty assessed against him in many standardized testing techniques, still makes a rating of above average intelligence. His intelligence quotient by the Terman modification of the Binet-Simon tests is 120, giving him a mental age of ten years and nine months. He shows no hearing defect. Audiometer tests place his hearing well within the limits of normal acuity with both ears. He has learned the meaning of a multitude of sounds in addition to those required for oral communication and he has stored memories of spoken words in good measure, serving the purpose of recognition of words when heard and as recall patterns which he uses in his own reproduction of them in speech. There are some slight inaccuracies here due to the omission of the minor modifications of the spoken word which follow familiarity with its spelling. He makes, for example, a rather poor differentiation in ordinary speech between such closely similar sounds as those of the short vowels ĭ, ĕ, ŏ, and ŭ, and between some consonants such as t and d, and f and v, but these would be caught only by the trained and expectant ear and his enunciation in general is precise enough to lead to easy recognition of his words by others. He is able to echo accurately speech sounds devoid of association when they are spoken by the examiner as nonsense syllables. Extensive somesthetic tests are quite within normal limits. He has a well developed stereognostic capacity and is quick to learn new motor patterns as evinced by his athletic prowess, his mechanical skills, and by pertinent laboratory tests. The accuracy of his movements in all of these fields (e.g., hitting a pitched ball, sawing to a line, or with the "steadiness tester") bespeak a good control of motor responses by the visual mechanism. When he was sent to the ophthalmologist at the suggestion of his teacher he was carefully examined both with the ophthalmoscope and by refraction tests and was discharged with a clean slate. Perimetric examination shows no restriction or indentation of the visual fields and there is no defect in color vision. His use of certain types of material gained through visual experience is accurate and certain. He does very well in the Healy Pictorial Completion Tests and perceives and correctly interprets an unusual amount of detail in the pictures which are presented to him in the course of the Stanford-Binet examina-

tion. He is observant of objects and quick to see the relation of parts in mechanical problems and can repicture spatial relations in new problems when they are verbally presented. His visual memory for places is so good that he is the most trusted guide of the family group in retracing routes on their automobile trips.

When we test him in reading, writing, and spelling, however, we meet for the first time in any of the fairly exhaustive examinations evidence of a condition distinctly out of harmony with his age, his intelligence, his alertness, and his skill in other fields. Although he is completing his third year in school, he obtains only a low first grade rating by standardized reading tests. Not only is he quite incapable of reading the words of the third grade assignments but he misreads many of the simpler words as well. At this age, he reads only a few words backwards and can distinguish *b*'s from *d*'s and *p*'s from *q*'s without error when given ample time but he remembers having had great trouble in telling them apart in earlier years. When confronted with a word beginning or ending with one of these "twin" letters, however, which is less familiar than another word of exactly similar spelling except that a *b* takes the place of a *d* he is still apt to misread that letter. For example, he is quite at home with the word "dog" but does not know "bog" as well and when "bog" is presented he reads it promptly as "dog. When assigned the task of cancelling all the mirrored or backward letters from a card on which both the ordinary and the mirrored forms are printed he makes a number of errors. One or two dextral forms are cancelled and several sinistral forms are overlooked. He takes a long time for this comparatively simple work and shows evidence of uncertainty and occasionally reaches a decision only after tracing the letter forms with his finger, thus selecting from the kinesthetic rather than from the visual clues. When he is asked to read from a card bearing a first grade test paragraph printed with reversed ("offset") type, he requires only about three times as long as he does to read a paragraph of comparable difficulty printed in the usual dextrad direction. Since those children of his age who have learned to read readily take about ten times as long for this task, our boy is seen to have a demonstrable mirror reading facility.

His spelling is atrocious. Such as he has shows efforts at phonetic reconstruction with very little evidence of recall of the appearence of the word. Since he has been in a school which stresses the "sight method" of teaching reading and in which phonetic training is tabu (until he takes up French or Latin) he has a very inadequate knowledge of which letters to choose for the sounds of the word which he has in mind and is thus enabled to mispell one word in two ways at once: first, by failing to recall its appearance and, second, by choosing the wrong letters to express his auditory memory of its parts. This produces the most bizarre results—often true neographisms.

His writing likewise lags strikingly. His manual dexterity however shows no impairment. He can not only draw very good pictures but he can draw each letter of the alphabet rather nicely and he can copy from printed text into his own hand with accuracy and with considerable neatness. When attempting to write to dictation or in original composition, however, his uncertainty of spelling leads to a slow and laborious production with many changes and erasures. Among his errors, in both dictated and spontaneous writing, are an occasional *b* substituted for a *d* and a not infrequent reversal of a pair of letters or a whole syllable. Some

of these errors are noticed by him and are altered or erased but most of them escape visual recognition. The stock of words which he can recall in graphic form is so small as to rank his writing capacity with that of a first grade child.

I have drawn this composite sketch for you to show the completed picture as I have pieced it together from the study of many cases and while it is confessedly a synthesis I believe it to be only slightly if at all, idealized. To recapitulate this story we may say that we find no difficulty of any type recognizable by our present methods of examination in the general intellectual level of such a boy or in the auditory, somesthetic, or motor fields. In his visual capacities we find him well equipped as far as the usual eye examinations are concerned, able to use his vision skillfully as a guide to motion, and to have stored for practical use a wealth of visual memories of form, size, color, and spatial relations of objects and of his environment but quite unable to use these visual accomplishments in reading and writing.

Further evidence of the availability of a wealth of visual material when reading has been lost is to be found in many cases of the alpha-privative syndromes although here it is seldom so clear-cut as that quoted above. The alexic patient can no longer read words but usually can and does make use of a wide range of visual memories below the word level both in recognition and in recall. A striking example of this has recently come to my attention. The patient was a woman past middle age who had suffered from a vascular accident and as a result showed a considerable degree of aphasia and an almost complete alexia and agraphia. When she was preparing to come to the hospital for a period of study she wanted to give her maid instructions for the packing of a traveling bag. She could not give the list of articles verbally nor could she write it spontaneously although she knew exactly what she wished to take with her. Some one had, however, given her a set of "aphasia cards" and from the pictures on one side of these cards she selected those representing the articles she desired. Then turning over each card she copied the name of each article and appended a number to indicate the units wanted. The copy made from print was produced in script and in her accustomed hand. There was no evidence of hesitation or uncertainty apparent in the product. She had constructed a complete and legible list in a good script. Here again we are confronted with a patient who was unable to read but who could still use pictures of objects as

symbols and could even write from copy although she could not do so by recall of previously implanted patterns.

Clearly the complexity of the visual material available both to this patient and to our strephosymbolic is far above that which can be allocated to the known functional perquisites of the first or arrival platform of vision and yet in both the function of the third or word level of visual elaboration is almost completely disordered.

An unsolved problem of localizing value further emphasizes the need for careful clinical separation of the functions of the second from those of the third level. We are not yet sure in how far one hemisphere may serve for the other at this level as is obviously possible in macular vision at the first level. In other words, we do not yet know how much of the agnosias result only from bilateral lesions of the secondary sensory cortices or in how far they may follow a unilateral lesion of the same cortical field if it involves the dominant hemisphere. The evidence of past studies is conflicting and it seems entirely possible that there may be wide individual differences here, dependent on physiological usage or on age and habituation.

Unilateral control is well established as the principle of physiological organization at the third or language level but unfortunately we have no direct method of determining which hemisphere is the dominant one except through observations and tests of the side of the body preferred in certain acquired motor skills. There is no method of auditory examination for determining whether the language functions derived from this sensory system are organized in the left or in the right hemisphere, and this is true even when a lesion has disturbed this function. In vision I think that some of the testing methods which have been devised in connection with the examination of strephosymbolics give hints as to the preference for one side or the other (or, more commonly in this group, as to the degree of hemispheric ambivalence) but in general we must turn to a study of handedness which is very untrustworthy because it is so exposed to the influence of chance or of purposeful training.

When we come to evaluate the evidence as to the origin of a physiological superiority of one hemisphere of the brain on the basis of this, as yet sole-available criterion, it becomes evident that some children start out with a decided preference for the right or the left hand, as the case may be, at quite an early age, but that many are obviously indeterminate in this particular for a considerable period of their

infancy or childhood. The numerical relations of right- to left-handedness in the adult, together with the familial occurrence of preference for the left, have led the geneticists to assert that these conditions follow the classic laws of heredity with right-sidedness operating as a Mendelian dominant. The occurrence of many individuals who in early life do not develop a strong preference for either side is also entirely in harmony with the hereditary viewpoint since it has been experimentally demonstrated that repeated crossings of heterozygous stocks do not result in complete segregations of the dominant and recessive characters but that intergrading occurs resulting in varying degrees of mixture of the two. When we approach the problem of handedness with such intergrades in mind the issue is seriously complicated by the very large part which is played by training in the acquisition of motor skills. So large indeed is this factor that an answer to the problem of handedness in many children probably cannot be obtained by *tests* but requires a *diagnosis* based upon the findings (often contradictory) of a large series of tests and observations, and upon pertinent information from the developmental history of the child in question. This obviously negates the value of a very large proportion of reported studies of the past because of their dependence on inadequate or poorly conceived initial testing.

The confusing factor of chance or purposeful training of the child operates chiefly to prevent an expression concerning the numbers of intergrades rather than their occurrence. There seems to be dependable evidence of delays in choice of a master hand and of mixtures of the sidedness patterns, which bespeak a dextral-sinistral intergrading, even after due allowance has been made for the effects of training. It is obvious that comparable variations and delays in acquiring the relations which exist between the two hemispheres of the brain in the adult would result in disorders and retardations in the development of the language faculty and we believe that it is from among these hereditary intergrades, with some additions resultant from forceful mistraining and some which follow brain injuries or diseases at birth and in infancy, that the major part of the special language disabilities arise.

If we accept the influence of heredity as a potent factor in the development of handedness—and I believe that such acceptance will follow with anyone who has not made an intellectual assignment to the extremists of either the environmental or the hereditary schools but

who still considers that both factors interplay in determining the final picture—we must, I think, accept a structural basis for this transmitted character. It is, as far as present knowledge goes, impossible to accept the transmission of a character of purely functional nature and we must assume that a structural superiority of one hemisphere underlies the fixed physiological preference given it in the development of the third level functions in both the complete dextrals and the complete sinistrals. However such structural superiority might quite conceivably be passed to the child in any one of three ways: First, there might be a better equipment of all of the cortical mechanisms of one side giving a complete hemispheric superiority; second, there might be a more complete or more mature structure in one major cortical division only (e.g., the auditory) with gradual spread of the physiological pattern of unilateral use to other areas; or, third, a better structure might develop independently in the two hemispheres in connection with each major functional division. A solution to this problem will clearly not be forthcoming until much wider studies have been made, but we may tentatively review the evidence which is at present available.

The functions of word understanding and of speech (unilateral mechanisms in the adult) are frequently developed with normal progress in children before there has been a definitive choice of a master hand or in whom there are demonstrable mixed patterns of dextrality and sinistrality. On the other hand some children have clearly arrived at a selective choice of one hand or the other before spoken language has reached its expected development for their age. The complex visual integrations requisite for the understanding and reproduction of graphic language become available to the child at a much later period than the auditory background of spoken language or the motor preference for one or the other hand. The usual period at which children, by and large, can be taught to read and write seems to be about the sixth year and it is probably this factor which has determined the beginning of formal schooling at this age. There are of course many variations from this in both directions and among these are to be found the striking retardations in otherwise normal or even superior children who suffer with minor grades of strephosymbolia. The more severe degrees of this condition illustrate clearly, as outlined in the type case described above, that development may proceed normally in the auditory, kinesthetic, and motor fields but

that there may exist a very highly selective obstacle to acquiring the adult patterns underlying graphic language.

The fact that the two functions of acquiring spoken language and of making a choice of a master hand do not follow in the same sequence in all children speaks against the transmission of a total hemispheric superiority and against the consistent transmission of the dominance principle by virtue of a better structure in one area with subsequent spread of the habit through use. It suggests that cortices controlling these two functions may have a different hereditary urge toward structural complexity or toward early maturation and this is further supported by the evidence of delay in the visual language functions in the presence of entirely competent auditory and kinesthetic mechanisms. We are therefore considering, very tentatively of course but as projecting new problems for study, this concept of separable hereditary factors in the three major fields of the language faculty.

As has been mentioned above, the problem of unilateral dominance can be raised as a clear issue only in discussing the third or language level. The clinical analysis of cases of strephosymbolia indicates a disorder of exquisite selectivity involving only the third level of visual integration. For this reason an analysis of the reading errors encountered in studies of such cases would seem to be an excellent starting point for an attack on the nature of the functional processes to which the unilateral dominance principle applies.

Our earlier studies of the errors presented by the strephosymbolics in their attempts at reading indicated the presence of two major factors in this disability: first, failure in accurate recall of details of individual symbols and, second, failure in the recall of sequences of symbols in the order of their presentation. Inaccuracies of recall leading to failure of recognition or to confusions between symbols are to be seen freely in those cases of strephosymbolia which are studied soon after this disability has become apparent, i.e., at about the age of six to seven years and before these confusions have been straightened out by repeated efforts. Here we meet errors of various types. Some are confusions due to relatively vague similarities between letters such as *e* and *a* or *l* and *k*; others are due to failure of recall of the spatial orientation of a symbol. These are of two kinds: first, where vertical disorientation occurs as when *u* is mistaken for *n* and *p* for *b*; and second, where right and left disorientation occurs as when *b* is mistaken for *d* and *p* for *q*. This latter type of error is by

far the most common in practically every case and if individuals be followed during retraining experiments this sort of mistake will be found to be the most refractory. One of the interesting observations here is that this error is not a fixed one, i.e., the child does not consistently miscall *b* as *d*. If this were true, he could soon be taught to correct his mistakes. Apparently there is almost a complete equivalence in these two symbols so that at one time the letter is correctly recognized and again it is given the name of its twin. This ambivalence was one of the elements which led to my suggestion of a *hemispheric rivalry* as the major factor in strephosymbolia. Usually these failures to differentiate the symbols accurately, except for a minor persistence of the *b–d* and *p–q* confusion are comparatively easily overcome by proper retraining methods. When strephosymbolic children attempt to write letters, errors of this type are readily apparent in their product and among these are frequent substitutions of *b* for *d* and *p* for *q*. Apparently it is possible for the orientation of these symbols to be implanted with sufficient security to enable visual recognition of them and yet to be insufficiently linked with the kinesthetic element to assure their correct graphic reproduction. Thus some children learn to tell *b* from *d* when seen but may write *d* when *b* is dictated to them. The graphic records thus often give additional evidence of the ambivalence of antitropic letter forms.

In considering failures in recall of sequences, we find in the reading disability a wealth of suggestive material. Indeed, except in the most severe cases and those with very inadequate training, the mistakes in the recognition of individual symbols usually disappear or are reduced to a relatively unimportant place quite early and those of sequence form apparently the chief obstacle to reading. Here again as in the simpler errors, both true sinistrad reversals and more gross disorientations occur and there is again a strong suggestion of ambivalence. Thus the word *was* may be interpreted as *was* or as *saw* interchangeably at different encounters. With many children however, especially as they get older and the emotional stress of their failures becomes more severe, the reversals are less prominent in the picture than are the complete failures in recognition and the substitution of other words which often have only the scantiest of visual similarity. It is important therefore in order to get a true perspective of the problem to study cases at various stages. Even more instructive are progress studies of the same child over a period of time and these

bring out the difficulty of sequence building rather strikingly. One such child who had learned no reading up to her third year in school mastered in a comparatively short period of special retraining the sequences of combinations of three letters so that she rarely made a mistake but when tested with the six letter word "repast" she read it as "ast-rep." She had clearly maintained the dextrad sequence for each three letter unit but had then combined the two units in sinistrad order. For testing this sequence building capacity, phonetic nonsense syllables (i.e., devoid of meaningful associations) and nonsense "words" composed of two, three, or more syllables, make excellent material. One child who had considerable difficulty in her reading had reached the point where she could read correctly almost all of the test list of one and two syllable nonsense "words," yet stumbled badly on those of three syllables and was entirely at sea with longer ones. When she was asked to read separately each of the four constituent syllables of one of the longer test combinations she did so perfectly but a synthesis of one "word" from these was entirely impossible without numerous errors which were mostly elisions or confusions of the order of sounds in the syllable or of syllables in the word—some of them sinistrad reversals. This difficulty in synthesis of sounds and syllables in unfamiliar long words is often encountered in older children as a remnant of an earlier reading disability and may be a serious limitation to their acquisition of information through reading or in learning foreign languages.

Our recently reported studies of the isolated disability in spelling bear out the suggested importance of the sequence factor here also. They however add an element of interest since many pathological spellers showing a striking failure in the visual recall necessary for the spelling of many words in English are yet good silent readers. Obviously the visual engrams here are sufficiently well implanted and integrated to permit recognition but not to serve in recall.

In our studies of the special disability in writing[1] this difficulty with sequences is again seen. Many cases of retardation in acquiring writing are associated with the reading disability or with the apraxic factor of an obviously mistrained left-handed individual but in some the writing difficulty seems to exist in practical isolation. In the younger children of this group troubles are encountered with the recall of the patterns needed to reproduce individual symbols. The *b–d* and *p–q* confusions are among the most frequent but those of in-

version, such as *n* and *u* and *m* and *w* are also met as are those dependent apparently on very slight similarities as has been mentioned above. Individual letters and also numbers are also frequently recalled and written in a sinistrad orientation; indeed on the same page one will often find a given letter written in its correct form in one place and in the reversed orientation in another and the child will frequently show his confusion by stopping to ask, for example, "Which way does a *J* go?". Usually however this stage is passed quite early but the easy construction of sequences of the individual symbols required for cursive writing lags sadly behind advancement in other language acquisition. That this is not a difficulty of coördination of the finer muscles of the hand as it is sometimes erroneously called is obvious from the presence of other finger skills such as drawing, piano playing, etc., in many cases. This marks the writing trouble as a specific disability in such individuals. In one case there was a considerable degree of skill with the pencil in sketching and individual letters were well drawn with the right hand, but cursive writing in the ordinary form, in spite of much practice, remained a difficult task and yielded a very poor product. There were no skills of note in the left hand but when mirror writing was attempted for the first time with the right hand the result was so much better than the dextrad efforts as to be astonishing. This case with others of similar nature gives the most suggestive recent evidence in support of the thesis of interhemispheric ambivalence or rivalry offered as an explanation of the *b–d* and *p–q* confusions, the tendency to sinistrad sequence building and the unusual skill in mirror reading to be found in typical cases of strephosymbolia. Cases with the writing disability are not always poor readers and it becomes obvious therefore that the visual engrams may be brought into adequate association for recognition and yet fail to enter into the linkage with the kinesthetic necessary for graphic reproduction.

Following the leads offered by these studies of interference with the acquisition of graphic language we have begun some investigations of disorders of certain other functions which are known to be controlled in the adult mainly or exclusively from one hemisphere. These extensions are in their infancy but a brief review may be offered of the trend which they seem to be taking.

One function of great importance to the child, in which unilateral dominance is the rule in the adult, is that of spoken language. This

naturally may be divided into the receptive and reproductive phases and we may in parallel with the aphasias thus anticipate sensory and motor types of speech delay. The difficulty of analytic separation of these will be recognized by those who have worked with the comparable disentanglement of the sensory and motor elements in the language losses in adults but it is far more intricate in the child since these delays are usually encountered in quite young and often apparently very uncoöperative children. Sensory delay, i.e., retardation in understanding speech, will obviously also retard oral speech development. The usual criterion, that of understanding speech, which serves fairly well in aphasics is often undependable since it is very difficult to evaluate the attention factor in such children. Some of them indeed seem to be particularly prone to disregard spoken words and to pay a greater degree of attention to visual and kinesthetic stimuli, resulting apparently in an investigative urge which keeps them constantly on the move inspecting and feeling objects but more or less oblivious to speech sounds. This may be in marked contrast to their quick attention to other sounds in the environment such as the ringing of the telephone bell or music played on a victrola. Another difficulty which we encounter here is the apparent intimate relation between the development of the general intellectual capacity of the child and his capacity to learn spoken symbols. Clearly, delays in learning to recognize words will result in a picture very like that of feeblemindedness and indeed we may by studies of the language delays be approaching a better understanding of at least one type of this heterogeneous group. These complexities and technical difficulties of analysis of retardations in the acquisition of spoken language are such as to make our progress here slow and laborious.

One of the first requirements in investigating the problem of these children is a measurement of their auditory acuity. Some aid is often given here by the history but not infrequently the parents themselves are in a quandary as to how much the child actually hears and bring this forward as one of the questions for which they demand an answer from the examiner. A frequent factor encountered in the history and in clinical observation of this type of case is the great variability from time to time. Occasionally the child will respond pertinently to words spoken in a very low tone and again will pay no more attention to them than we do to the noises of passing traffic. Tests with the audiometer are of great value in children who are old

enough to coöperate in them and this age may be extended downward somewhat by means of the train and tunnel adjunct devised by Dr. Ewing of England. In several of our patients whom we at first thought to be cases of congenital word deafness we have found a significant drop in the auditory acuity, in both ears, in the upper ranges of the frequencies used in speech and have thus been led to consider them tentatively as cases of partial cortical deafness rather than of selective word deafness.

However children are sometimes seen having little or no evidence of a motor speech block and adequate hearing, and yet with a severe retardation in the understanding of spoken words and consequently also in learning the patterns needed for oral reproduction of them. Any opinion as to the intellectual capacities of these children must, I believe, be held in abeyance without prejudice since it is clearly obvious that defects of language understanding will retard the apparent intellectual development of the child and that the only just measure of latent abilities will rest on an evaluation of his learning capacities by other pathways than the auditory and by the results of specially designed methods of retraining for word understanding. In certain of our cases such experiments seem to indicate fairly clearly a latent educability far beyond that which would be inferred from the word understanding.

In the efforts at speech which these children make we are finding again, I believe, factors comparable to those of the reading, spelling, and writing disabilities. Many single sounds are so poorly differentiated by these children that we may tentatively infer that they are not well recorded as auditory recall engrams and thus give rise to errors analogous to the simpler errors of recall of individual units in the reading disability. When we come to the question of sequences of sounds, however, it must be borne in mind that the situation is one in which the time factor rather than that of spatial position is of importance. In recalling visual sequences in the printed word it is the spatial relations of the letters which is important. In spoken words however it is the temporal relations of a series of sounds which interest us. This is in harmony with the obvious functional importance of space and time in vision and audition.

The reproduced sequences of children suspected of congenital word deafness exhibit a wealth of errors. Many of these are inadequate pronunciations or sound elisions from the proper sequence for a par-

ticular word. In a few instances we have recorded true temporal reversals in pronunciation of short words, such as "nap" for "pan" and "naf" for "fan." These however are rare in our present experience. Somewhat more common are reversed reproductions of the units of compound or paired words such as "comb-hair" for "hair-comb." One of my boys says he lives on "Driverside River" (Riverside Drive). With older children of this general type the errors may be sufficient to result in true neologisms such as "ardless" for "astronomer" and "flooshy" for "flying ship."

We have not yet perfected tests by which to estimate the competence of the second level of the auditory function in these children, i.e., the hearing and recognition of sounds, but their general reactions to sounds of the environment would strongly indicate that this function is normally developed, thus paralleling the situation to be found in the second level of the visual function in strephosymbolics.

Stuttering forms one of the disorders of spoken language which often expresses itself in early childhood. With adults or adolescents who have stuttered for years there is commonly so great an overlay of emotional factors as to render the picture very confusing. When however the patient is seen in childhood, soon after the disability is first apparent, he often seems singularly free of undue fears, of self-consciousness, or of the overweighted attachment to his mother which are so often interpreted as bearing a causal relation to stuttering. Examinations of such children will almost without exception show normal reflex movements of the chest and abdomen in respiration and usually normal echo repetition of individual sounds and short words but great difficulty in integrating these units into the motor sequences required for propositional speech. In stutterers seen in early childhood other dominance problems such as retarded speech development, delay in choice of a master hand, or mixed handedness patterns are frequent. With those whose speech disturbance begins between six and eight years of age, delay in reading, in spelling, and difficulty in learning to write easily are very common complications. Many stutterers are, however, bright or even precocious in their acquisition of reading skill and are apt with their hands. The great variability in their fluency of speech from one time to another is a common observation and suggests an interesting parallel to the variability in the recall of the visual and auditory engrams at the third level noted in the strephosymbolics and the word deaf children.

This group is most apt to have a strong family history of stuttering uncomplicated by other language delays and apparently passing more frequently from father to son than otherwise. We are hoping for further aid in understanding this disorder through extended studies of the bilateral action current patterns obtained by the oscillograph which are at present under way, and will be reported upon later, but we are tentatively interpreting stuttering as a failure in the kinesthetic or premotor integrations requisite for combining the simpler reflex units of the breathing mechanism, the larynx, the tongue, and the lips into the extremely complex sequence of movements which are necessary for fluent speech.

Our studies have in the main been centered about the language faculty and its disorders but we have naturally encountered deviations in the acquisition of other functions which in the adult are known to be under unilateral cerebral control, occurring as complications of speech and reading disorders. Among these is the difficulty met by some children in learning intricate movements and this is occasionally of such severity as to merit classification as congenital apraxia. In such cases there is an unusual difficulty in learning those motor patterns which are not of the simple bilateral or alternative type of long phylogenetic ancestry but which require a recombination of fractions of these simpler reflex acts into more complex movements and particularly those movements which depend more or less on mimicry and hence on a repicturing of the motions of others. Thus we would not include here standing, walking, crying, laughing, swimming, and postural control but would include throwing, drawing, writing, dancing, and a great range of other acquired skills and especially those in which the hand is used. It seems probable that it is this condition which has given rise to the implications in the use by the French of the word "gaucherie." It is unfortunate that this should bear the connotation of awkwardness for while this is often to be observed in the left-handed it seems in our experience to be more frequent in those with mixed handedness. Many left-handed individuals are exceedingly skillful in athletics, in mechanics, and in art. The problem of the "gaucher" therefore seems to be not that of left versus right but that of lack of predominant skill in either.

Naturally the prosecution of these studies in the language delays is having its repercussion on our approach to the alpha-privative syndromes. It has long been apparent that the extent of the func-

tional losses in the language faculty can not be brought into correlation with the extent of the structural damage which has produced them. A very small lesion in the angular gyrus region in one patient, for example, may result in as widespread a disturbance in reading and writing as a much larger destruction of the same area in another case. This bears equally heavily against the "mass action" theory of cerebral function as propounded by Lashley from his studies of rat brain exsections and against the theorem of the precise pigeon-holing of functions of the older localizers. It is however conformable to the concept of a reduction of physiological supremacy of the master hemisphere for those integrative processes which are dependent on the integrity of the affected cortical locus. This makes of the aphasias as much of a physiological as an anatomical problem. The practical equivalence in structure of the third level cortices of the two hemispheres raises the intriguing question of the possible latent physiological potencies of the undamaged non-dominant hemisphere in cases of aphasias resultant upon unilateral lesions. Here the problem of rivalry between a damaged active area and an intact though previously inactive area is pertinent. Our own studies of the alpha-privative syndromes are as yet too few and incomplete to be of much value in answering these questions but a number of our observations suggest the occurrence of rivalry and show the presence of disorders in the process of recall and reproduction of sequences.

DISCUSSION

The following questions submitted to Dr. Orton before the Commission, together with the answers to them, are here reported verbatim.

Dr. Frederick Tilney: I simply want to express my great appreciation to Dr. Orton for his presentation of this subject. I have been in fairly close contact with him for several years now and know the kind of work that he is doing. I think from what he has done so far, that it looks very much as if the principles which he is establishing are going to extend themselves far beyond the speech function and take us into much broader, deeper fields of psychology, at least that is the way this work appears to me.

Dr. Bernardus Brouwer: I appreciate very much the work of Dr. Orton but I have not so much experience in this line. I would ask only one question. There are some findings in literature about these children from the anatomical side. Can you give some important data of these cases, chiefly of the inborn speech

disturbances? There are some I remember but they are not in my conscious knowledge.

* Dr. Samuel T. Orton: My impression is that those who have shown that have shown also difficulties demonstrable at the lower levels, in other words, the cases of defect in hearing, auditory defect, also show a reduction in the hearing acuity, and that type of case we have seen also.

Henshel Wood's original idea of congenital word blindness, as he called it, or strephosymbolia, as I have called it, was that it was due to a true defect in development, an agenesis of what he calls the area for word memories or visual word centering. Of course, we have given up the exact pigeon-holing of the localizers of that day. We do not feel there is such a predestined area, and even if there was an agenesis there, adjacent areas would probably take on that function if it were an agenetic phenomenon. The thing that interests me is this, that if that were true, we would certainly find those agenetic areas in a great many brains, because we have rather definitely decided they are definitely determined. The reading disability is present in a demonstrable grade enough to be a serious obstacle to the start of the child's reading in about 6 per cent of the total school population.

* (Hinshelwood's)

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SPECIAL DISABILITY IN SPELLING

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As the writer has previously emphasized (1) a large part of early academic education is, from the neurological standpoint, a building of associations between visual symbols and previously acquired auditory memories of words. In almost every child a very considerable development of the language function has taken place before he encounters any academic training. Before he enters school he has spent several very active years in the acquisition of verbal memories and the building of linkages between these and the object or concept which they represent and in developing as the motor counterpart thereof his own powers of reproducing these auditory engrams in speech. In school he is faced, usually for the first time, with the task of learning to arouse these word storages and their accompanying meanings through a series of symbols, each of which, in a language based on a phonetic alphabet, represents one sound of a series which constitutes the spoken word. At the same time or shortly thereafter he is introduced to the reproductive component of written language, that is: to the translation of the sound sequences of words into their corresponding letter names, as in oral spelling, or into their graphic symbols, as in writing.

The process of learning to read, which plays so critical a part in all academic training, is subject to marked variations which can not be correlated with the general intellectual powers of the individual child and the writer has called attention under the name of strephosymbolia (2) to a specific obstacle in learning to read which exhibits itself in certain characteristic errors and which is believed to represent one expression of an heredity variation in the establishment of the complete unilateral cerebral dominance which obtains normally in the physiological control of the language function.

Current neurological practice recognizes an exceedingly precise

localization of certain brain functions. This applies particularly to the functions which belong to the lower levels of cerebral elaboration, i.e., those pertaining to the projection systems. Uncomplicated lesions occurring in these fields express themselves in such symptoms as Jacksonian attacks, upper motor neurone paralyses, central anesthesias and hemianopsias, which play a most important and trustworthy part in localizing diagnosis.

In the higher elaborations, however, there has been a change from the older views of an exact, circumscribed, and constant localization of these more complex functions. Particularly is this true of the very intricate patterns underlying the language faculty and there is now a tendency to look upon language as a complex tripartite associative process in which data of visual, auditory, and kinaesthetic[1] origins are brought into varying relationship. Pending the acquisition of more exact knowledge the cortical field in which this process is carried out is accepted as the rather wide zone of the third level cortices which occupies a considerable area in the temporo-parietal regions. Opinions vary strikingly among neurologists as to how far a fixed pattern of localization may exist within this zone. This forms one of the most challenging problems of present neurological science and practice. Regardless, however, of the ultimate solution of this question there is one major variable which is universally recognized. This is the fact that in a given individual one hemisphere—which is designated as the dominant one and which may be either the right or the left—plays a part of much greater functional importance in the language faculty than does the other. It is cardinally important to our studies of cerebral physiology, however, to recognize that

[1] For the sake of simplicity the term kinaesthesis will be used throughout this article to designate the function of the area immediately back of the Rolandic fissure. It should be remembered, however, that kinaesthesis, strictly speaking is probably only one part of the function subserved by this cortical field and that we are here dealing with an aggregate of the epicritic fractions of all of the sensory relays which find their way from the surface of the body by way of the spinal pathways—not only, as the term would imply, those from muscles, joints, and tendons. Thus we include here that fraction of all of the non-projicient exteroceptors—touch, pain, and temperature—as well as the proprioceptors—the true kinaesthetic. I know, however, of no inclusive term which delimits this aggregate of fractions.

this concentration of functional values in one hemisphere is not a universal rule in all cerebral functions but appears only at the highest level of cortical elaboration to which we also ascribe the language faculty. As the writer has pointed out elsewhere (3) there are striking differences in the interhemispheric relations at the same level of integration in different functions as well as at different levels of any one function. The motor cortices and the lower kinaesthetic levels operate as independent unilateral organs. This arrangement is in harmony with the physiological requirement of separate motor control of the two sides of the body and equally so for the need of separate recording of the exteroceptive and proprioceptive sensations from each half of the body. Thus it is cardinally important to the organism that pain stimuli, for example, received by the brain from the right hand, be differently perceived and separately recorded from those arising in the left, in order that motor responses resulting from such stimuli be related to the proper side. This functional separation is of course clearly exhibited in the unilateral effects of lesions in the precentral and postcentral gyri of one hemisphere. A very different physiological need, however, exists in the case of two of the projicient exteroceptors—vision and audition. Here the independent recognition of stimuli received by each of the two symmetrical receptor organs would lead to confusion and some mechanism must be established to permit of the correct interpretation of the stimuli originating in a single point of light, for example, but relayed simultaneously from both retinae to both cerebral hemispheres. Two sorts of physiological mechanisms would be theoretically possible to meet this need: first, the two hemispheres might operate by rivalry with one attuned to the incoming stimuli and the other inhibited or, second, they might operate as a unit by a process of physiological fusion. There is evidence to suggest that in certain animals the principle of rivalry exists but Sherrington has convincingly shown that in human vision there is complete bilateral fusion. The visual function can not, however, be looked upon as a unit in this regard since peripheral vision is differently innervated and differently affected by a unilateral destructive lesion in the brain than is macular vision. Macular vision is not

lost in a unilateral lesion and there seems to be no striking difference in this regard whether the lesion occurs in the dominant or in the subordinate hemisphere. The plan of bilateral fusion seems to be the rule in audition also, although I am aware of no such concrete studies of this topic as Sherrington has given us for vision.

At the second level of cerebral elaboration there seems to be evidence of a bilateral fusion in vision and audition. The severe disturbances of these two functions resulting in mind-blindness and mind-deafness apparently occur only in the presence of extensive bilateral lesions of the corresponding sensory fields.

From this and other evidence it may be tentatively assumed that in man the lower platforms of the two hemispheres act independently in kinaesthesis while in vision and audition they act together as a functional unit and this introduces the very interesting relation existing between the two hemispheres at the third or language level. Neither the principle of independent action which is seen in the lower levels of kinaesthesis nor that of fusion which is seen in the lower levels of vision can be applied to this zone since in this higher function one hemisphere seems to be of prime importance while the activity of the other is almost if not entirely negligible. Lesions of the language zone in the dominant hemisphere give rise to a large group of symptoms—the alpha-privative group (aphasia, alexia, agraphia, etc.)—while those in the subordinate hemisphere remain "silent."

It should be remarked, however, that there is no such contrast in structure of the two hemispheres as is seen in function. Certain differences have been noted by various authors and held to explain the superiority of the left or right hemisphere, but such differences are exceedingly small when compared with the overwhelming functional importance of the dominant side. The third level cortices of the subordinate hemisphere seem about as well developed in extent and in detail as do those of the dominant side. Certainly there is, in the subordinate, a mechanism capable of receiving neural irradiation and registering it and it seems logical to suppose that the much greater importance of the dominant hemisphere rests on the establishment of a physiological habit of use of

that side rather than on any great anatomical inferiority of the other. Failures in the acquisition of this habit of exclusive use of one hemisphere would lead to the conflicting persistence of the records in the other and to consequent confusion.

The existence of unilateral dominance in man raises a question of sufficient theoretical interest to warrant a slight digression, viz., What is the mechanism in all of the symmetrically built axial animals which serves to prevent ambivalent confusion? That ambivalence of sufficient degree to cause motor antagonisms between the two sides does not occur to any striking degree is evinced by the ease with which both instinctive and adaptive reactions are carried out by such animals, and such an adjustment must indicate either an alternating dominance (i.e., a rivalry) or a fixed unilateral dominance such as is seen in man. The principle of phylogeny of the central nervous system is demonstrably one of superposition of new levels of neural mechanisms on those of earlier establishment, with the maintenance of a large degree of autonomy at the lower levels but a subordination to a measure of control by the highest. Obviously a more or less complete bilateral equivalence would be a functional possibility at all of the lower levels and theoretically dominance, either transitory or fixed, need reside only at that critical level where a reaction must be determined on the basis of the importance to the animal of various simultaneously arriving stimuli, or, in other words, where a choice of alternative motor responses may be made. This critical level is in the cortex in mammals, and in the human brain it would seem possible to still further delimit its residence to the third level of cortical integrations which constitutes the seat of higher mental functions and which as outlined above is the first point at which definitive unilateral dominance emerges in man's brain. The question of whether or not a unilateral control exists in animals of lower cerebral organization than man must be approached with due regard to the critical isolation of reaction patterns which are under the sole control of the highest neural mechanism of that particular animal.

Either hemisphere in man may play the dominant rôle although the left functions in this way much more frequently. The

two most readily observable diagnostic signs of left or right cerebral dominance are the master hand and the master eye. The more skillful use of the right hand in trained acts and particularly in those requiring a high degree of associative integration such as writing is usually held to be sufficient evidence as to the existence of a left hemispheric dominance. Obviously, however, the influence of training, either consciously or unconsciously applied by parent or teacher, may in many instances modify the native patterns of a particular child so that the value of this single observation is largely nullified. Moreover an encouraged or enforced shift to the right hand in writing has been so common a practice in the past and still exists in so many localities that the record of the hand used for writing is an exceedingly untrustworthy guide to dominance. Frequently mixtures of handedness patterns appear under observation and by test which leave the investigator quite in the dark as to how far the natural or inherent master hand has been influenced by the training to which the individual has been exposed.

The master eye has been held by some to be a safer guide to native dominance than the master hand. The master eye may be defined as the eye chosen by habit when for any reason there is an enforced use of one or the other eye, as when peeking through a small hole or sighting along a straight line such as an arrow or a rifle barrel. Tests for eyedness are simple and very easy to carry out but, as with handedness, too much dependence should not be placed upon a single method. Since the master eye occasionally exhibits the greater visual defect it would appear that this phenomenon does not rest on visual acuity, but is an expression of motor control of the eyeball in sighting, comparable to handedness. The occurrence of left eyedness in an individual with a distinctly greater skill in the right hand in trained movements is fairly common. This is especially true of those who give a history of left handed tendencies in infancy and a shift to right handedness by training and it has been held by some writers that since eyedness is less subject to modification by training than is handedness, the master eye of a given individual will serve as a diagnostic index of his inherent pattern and that all right handedness in left eyed

people results from training. The occasional finding of a clear-cut right eyedness in a person who uses the left hand by preference in all skilled acts tends to negate this assumption and supports the thesis that these two motor patterns may occur as inherently separate functions.

Left handedness has been the subject of studies in inheritance and has been held by geneticists to be transmitted as a Mendelian recessive. Since left handedness is merely one of the expressions of right cerebral dominance this may then be restated in this form: The selective use of the right hemisphere in control of highly skilled movements is determined by heredity as a recessive character. However, strict Mendelian segregation between dominant and recessive characters can be expected only when dealing with matings of homozygous stocks. In other circumstances "intergrades" between the dominant and recessive characters are to be expected and the expression of this principle of intergrading in the inheritance of right or left cerebral dominance might readily explain delays in the choice of a master hand and interference with the development of skill in either. Moreover, one might well anticipate disturbances in the acquisition of other functions, such as the various components of the language faculty, which are normally dependent on the selective use of one cerebral hemisphere, and one might expect to encounter these variants more frequently in families in which left handedness occurs. These expectations seem to be abundantly supported by the facts. The writer has elsewhere reported (4) a series of family studies showing, in different members of three generations of eight families, the occurrence of language disturbances such as delayed speech, stuttering, strephosymbolia, and pathological writing. In the same families there were also, as might be expected, numerous instances of left handedness without language disturbance. Numerical studies of the distribution of strephosymbolia between the two sexes have brought out the fact that this condition is more frequent in boys than in girls by a ratio of about three and a half to one and it has long been noted that stuttering also is more common in males. These facts seem to suggest that the inheritance of some, at least, of these special disabilities in language

follow a partial sex-linked type of heredity rather than the strict Mendelian distribution.

The various special disabilities in language acquisition all bear the common "hall mark" of a failure in building facile associations between the various sensory engrams employed in the language structure. One of the most prominent obstacles to this easy association building is, as has been shown in the case of reading (2), the condition of strephosymbolia which is characterized by a confusion between a given symbol and its mirrored counterpart, by a tendency toward reversal of direction in reading so that words are read in part or as a whole to the left instead of to the right, and by a facility in mirror reading. All of these symptoms stand in fairly definite quantitative relationship to the severity of the disability (5).

Recognition of a symbol such as the letter *b* entails the comparison of the visual sensation aroused by that symbol with previous implantations (i.e., engrams) which have been built into a fixed association with the name of the letter or its sound or both. When, however, the recall of the implanted engram is not constant but may be either the dextral form (*b*) or its mirrored counterpart (*d*), and where the recall of a previously seen group of letters may be in either the dextrad or sinistrad order (as when *was* is read as either *was* or *saw*) it is clear that rapid and fixed associations between letters and sounds, and groups of letters and their corresponding sound sequences (words) cannot be readily built and there results a considerable degree of delay in learning such associations and many faults in the linkages which are established. This view that the confusions so arising do not rest on disturbances in the visual process but rather on an ambivalence or variability in the engrams with which the visual experience is to be compared forms the crux of the explanation which I have offered for strephosymbolia. It elucidates the great instability which characterizes mistakes between *b* and *d* for example, and explains the complete interchangeability of these two letters which is often seen, as when *rudder* is reproduced as *rubder*. Moreover the occurrence of these mistakes in writing would seem to be rather conclusive evidence that this confusion exists in the

registered engrams and not in the visual experience. I believe that the children with these confusions see as others do but fail to learn to elide completely one of the two antitropic engrams registered as a pattern for the later comparison which forms the basis of recognition. This view is derived from the neurological thesis of fused bilateral function at the lowest visual levels and complete unilateral dominance at the language level, and would tend to minimize the importance of eye movements, minor degrees of eye muscle imbalance and minor visual defects which have been so much emphasized by certain other workers in the field of reading disabilities.

Children with a marked reading disability are almost always bad spellers. Occasionally a poor reader will learn to spell fairly readily by rote auditory memory and when examined upon recently acquired lists of words will show a fair degree of skill. These implants, however, if not reinforced by the visual recall are evanescent and if such a child be examined upon a list of words one or two years below his current efforts he will generally be found to have lost many of the words which he knew at an earlier period. One such boy was reported by his teachers as attaining consistently high grades in the spelling of sixth grade words but when examined by graded tests he failed completely at the fourth grade level. A similar discrepancy may often be seen between a child's ability to pass spelling tests in school and his ability to make use of the same words in propositional writing. More commonly, however, spelling and reading skills are acquired at about an even rate and educational profiles show them keeping closely together. This is shown graphically in the profiles of three cases reproduced in figure 1.

Reading, however, requires a much less accurate degree of visual representation in the associative process than does spelling, and it is therefore not surprising to find individuals whose visual engrams are adequate for the recognitive associations required in reading but quite inadequate for recall and hence are not serviceable for spelling. In such cases the special disability in spelling may stand out as an isolated defect although not infrequently the history of the child's progress in school gives evidence of an earlier

reading disability. Here also the method of instruction in reading seems to play an important part and many of the children with isolated spelling disabilities are found to have been taught to

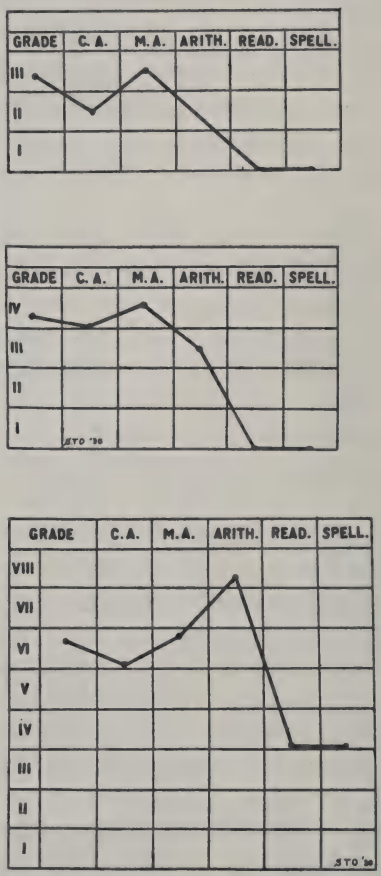

FIG. 1. EDUCATIONAL PROFILES OF THREE BOYS WITH A SPECIAL DISABILITY IN READING, SHOWING HOW SPELLING PARALLELS THE READING DEFECT
C. A.—Chronological age. M. A.—Mental age

read by the whole word or "sight" method which has failed to establish the sound association with individual letters necessary for the reproduction of the word in spelling. An educational profile of a spelling disability without a reading defect is given in figure 2.

Occasionally, bad spelling seems to be derived from a difficulty in association between the visual and the kinaesthetic engrams which results in marked retardation in writing skill. Apparently, the exceedingly slow and laborious writing of such children may have a secondary effect on spelling, especially where this is taught exclusively as a written exercise. In such instances there is at times a noticeable difference in ability between oral and written spelling. The cases of pathological writing can not be reviewed

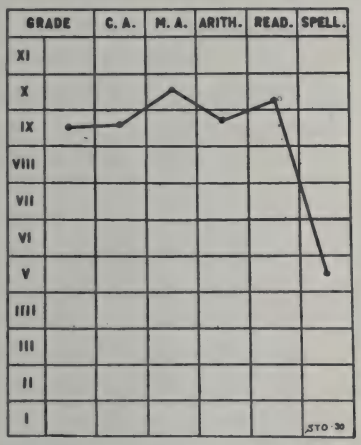

FIG. 2

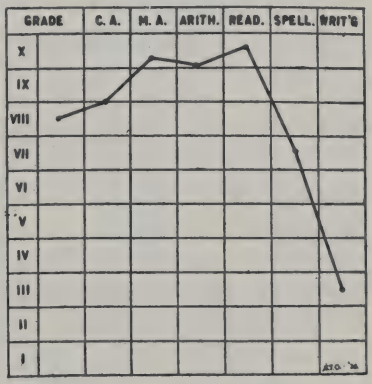

FIG. 3

FIG. 2. EDUCATIONAL PROFILE OF A BOY WITH A HIGHLY SELECTIVE DISABILITY IN SPELLING

C. A.—Chronological age. M. A.—Mental age

FIG. 3. EDUCATIONAL PROFILE OF A BOY WITH A MARKED DISABILITY IN WRITING AND A MODERATE DEFECT IN SPELLING

C. A.—Chronological age. M. A.—Mental age

here in detail but will form the basis of a later paper. Not infrequently, however, they occur in naturally left handed children who have been subjected to an enforced shift to the use of the right hand for writing. This was the case with the boy whose educational profile is shown in figure 3.

Usually an inability to spell is treated as of more or less minor importance, in sharp contrast to a reading disability. Occasionally, however, it reaches such a degree of severity, even where it

exists in isolation, as to form a definite scholastic handicap, as was the case with the boy whose educational profile is shown in figure 2, who was refused admission to the school of his choice solely on the basis of his spelling deficiencies.

The recognition of the existence of a spelling disability offers no difficulties but the accurate diagnosis of the character of the faulty associations which underlie the disability and which must form the basis of rational reëducational efforts is somewhat more complex. Where it is associated in a young child with a typical strephosymbolic obstacle to reading the special methods devised for the correction of this difficulty will also improve the spelling to a marked degree although it is probable that skill in spelling will be acquired more slowly than in reading. In the cases where an isolated spelling defect exists an analysis of the errors must precede any attempt at retaining.

The analysis which follows does not attempt a complete compilation of the types of spelling errors at large but merely a classification of those which have appeared most strikingly in the children whose retraining has been proceeding under my direction. The errors used as illustrations have been taken from the records of children with spelling disabilities of both categories—some with reading disability and some without it—and are drawn from both written and oral spelling of words and from sentences, usually given by dictation, although some are from propositional writing.

Confusions resulting from reversals of orientation of symbols whose mirrored form closely simulates another symbol are frequent in the younger children and in those presenting a severe reading disability. Such confusions between *b* and *d* are shown in figure 4, which is reproduced from traced replicas of written exercises in spelling.

In some instances the error was seen and corrected by writing over the mistake; in others it passed unnoticed. Since the child sometimes recognizes such errors after they are written and makes erasures and corrections, it is important for the examiner to watch the child at work as well as to study the finished product to determine the confusions that may be present. Some children spon-

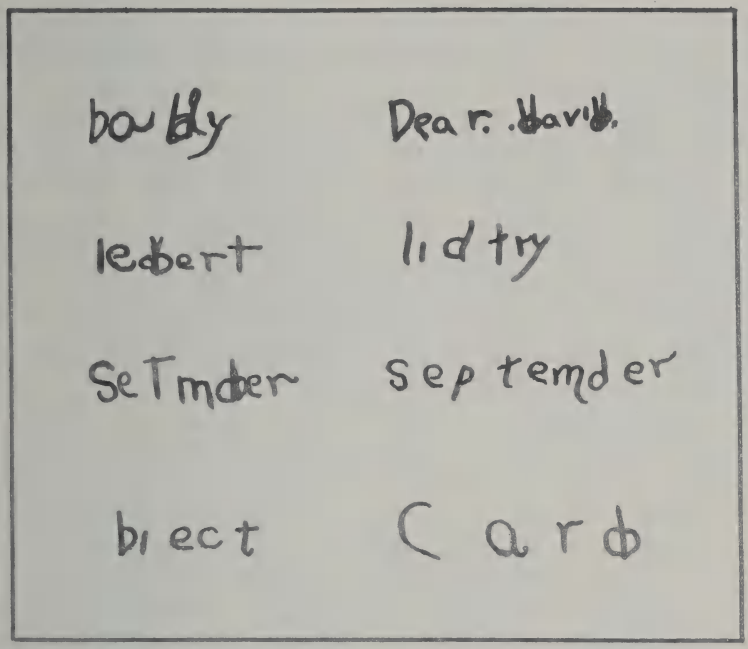

FIG. 4. GRAPHIC EVIDENCE OF CONFUSIONS IN RECALL OF *b* AND *d* IN ATTEMPTS OF SEVERAL CHILDREN TO WRITE THE WORDS *baby, David, liberty, September, direct,* AND *card*

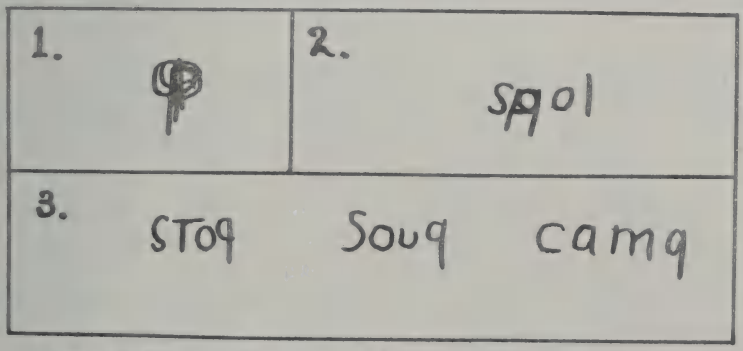

FIG. 5. GRAPHIC EVIDENCE OF CONFUSION BETWEEN *p* AND *q*
At *1*, writing *p* to dictation. At *2*, writing the word *spoil* to dictation. At *3*, writing the words *stop, soap,* and *camp* to dictation.

taneously resort to a kinaesthetic test and may be observed tracing both forms of the letter in the air to obtain a clue as to which orientation is correct.

Evidence of the complete interchangeability of these two letters is found in four efforts of a girl of ten to spell *because*. All of these occurred within five lines of a school exercise and were *decose*, *becars*, *decars*, and *becard*.

The comparable confusion between *p* and *q* is shown graphically in figure 5. At *1* is a tracing of the effort of the seven-year old child whose educational profile is shown in figure 1 to write a *p* from dictation, at *2* the product of a ten-year old child in trying to write the word *spoil*, and at *3* a boy's spelling of *stop*, *soap* and *camp*.

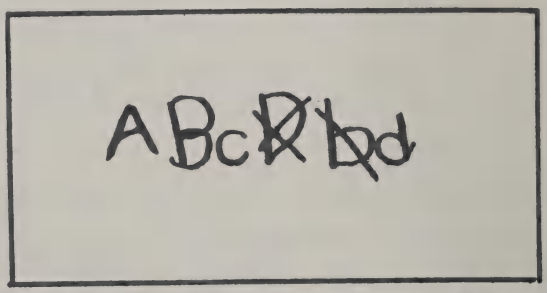

FIG. 6. USE OF CAPITAL *B* AND *D* TO AVOID CONFUSION BETWEEN THE SMALL LETTERS

The confusions arising between *b* and *d*, and between *p* and *q* through comparison with the reversed or antitropic engrams are obvious. Certain other confusions are less easy to see but are understandable when the letters are examined in a mirror or by looking through the page. Thus the lower case *f* when seen in mirrored form somewhat resembles a *t*. This confusion has been encountered a number of times in reading and is exhibited in writing in the work of a girl who wrote *transfer* as *transter* and *suffer* as *sutFer* although orally she spelled both words correctly. The mirrored form of a lower case *a* is somewhat like an *s*. Confusions between these two letters have been encountered in reading but I have not yet found them in writing. In children, who have been

taught manuscript writing, *g* and *q* are sometimes confused as illustrated by a thirteen-year old boy's spelling of *guess* as *quess*. The use of capital letters to avoid the difficult choice between letters whose lower case forms are antitropic occasionally points out the existence of a confusion. This is shown in the word *sutFer* and it also is seen to good advantage in the product of a seven-year old boy when attempting to write the alphabet from memory, as shown in figure 6. He started with a capital *A* and followed this with a capital *B*, thus avoiding the issue of differentiating the lower case forms. A small *c* follows but he returned to a capital at *D* and then when requested to make small letters he miswrote *b* for *d*. He recognized his error, cancelled it and then wrote a small *d*. The *b-d* and *p-q* confusions rest apparently on an ambivalence of antitropic engrams. In this there seems to be no progressional element and I have therefore listed this type in my records as "static reversals."

There is a second and more frequently encountered form of reversal in which the fault lies in the direction of progress rather than in orientation of the symbol. Here there is a tendency to assemble the letters in sinistrad or alternating sinistrad and dextrad order. This type I have designated as "kinetic reversals." As in the reading disability this tendency may exhibit itself in only a few letters of the word or in a syllable or in a whole word. (This is to be differentiated from mirror writing in which there is sinistral orientation of all the letter forms as well as sinistrad progress in writing.) The following list gives typical examples of misspellings due to kinetic reversals.

warm	wram	orphan	rophan
night	inght	idleness	dileness
girl	gril	accomplish	accompilsh
the	hte	improvement	emporvemet
afraid	afard	teeth	theet
eight	ieght	difference	drifence
elect	elcet	target	tagret
particular	particalur	direct	dierct
John	Jhon	expedition	expetidion
station	statoin	testimony	testominy

An interesting variant of the kinetic type I have recorded as an "in and out" reversal in which the child starts in from one end of the

word which may be either the right or the left end and after spelling through part or all of it then turns around and spells back again over the same letters. Thus *how* becomes *wow* if started at the right and spelled by this "in and out" method, or becomes *hoh* if this order of progress be reversed, and I have had both of these responses. Other suggestive variants of this process are seen in *gone* written as *goneg*, *green* as *greer*, *able* as *ablbe*, *retire* as *reteter*, *had* as *hah*, *good* as *goog*, and finally, as the most perfect example, *rag* spelled as *garag*.

Figure 7 illustrates kinetic reversals in writing. On the upper-line are shown three words in which the final letter has been

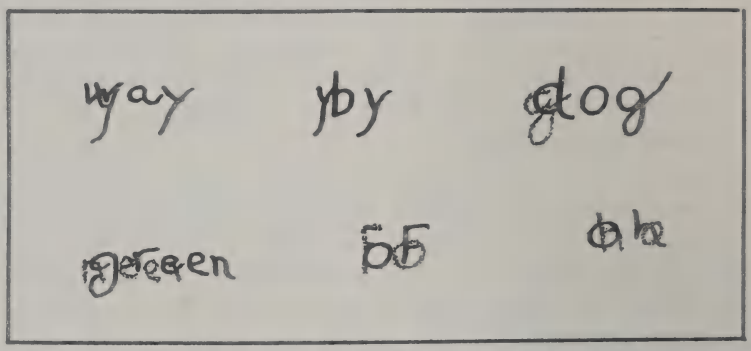

FIG. 7. KINETIC REVERSALS SHOWN IN THE WORDS *way*, *by*, *dog*, *green*, *of*, AND *oh* WRITTEN TO DICTATION
Explained in the Text

written first. In two of these the error was recognized by the boy who wrote them and would have been erased had he not been asked to leave them. The second line shows the product when a ten-year old girl was asked to write *green*, *of* and *oh* to dictation. In these examples the first attempts were erased but "ghosts" were left which could be readily seen. In attempting *green*, as will be noted from the figure, this child first wrote *n e e r* and saw her error only when she reached the final letter *g*. In writing *of* she produced *Fo* and then corrected it. This was one of the children to whom *f* and *t* were equivalent and the one who wrote *sutFer* for *suffer*. It is interesting to note in figure 7 the use of a capital *F* in *of* to avoid this dilemma.

The proportion of static to kinetic errors is markedly variable in different cases. In the younger children both may be found but apparently the static reversals are the more easily corrected since the older children usually show few or no reversals of this type.

Lack of constancy in the recall of either the sinistrad or dextrad engram as evinced in the two types of reversals is held to be the chief source of failure in establishing a quick association between the visual engrams of the letters of a word and their sounds. When this failure is severe it serves as an obstacle to the acquisition of both reading and spelling. Apparently it may exist, however, in a lesser grade which does not prevent the establishment of engrams sufficiently clear and constant for recognition and hence for reading. Such engrams however may not be adequate for the accurate recall of the "look" of a word necessary for the spelling of non-phonetic words or for the easy recognition of errors after they have been made. Not infrequently such a child will say of his own product, "That doesn't look right but I can't see what's wrong with it."

Naturally this failure to incorporate the visual element into the association throws most of the burden of spelling upon the auditory memory with consequent attempts at phonetic spellings. This results in many errors due both to the lack of a consistent phonetic structure in English and to specific false associations between letters and sounds operative in a given individual.

The vowels are a particularly fertile source of errors in spelling as they are in the reading disability. With a few exceptions the consonants require the building of but one association between the symbol and its sound and hence present a much easier task than do the vowels where multiple linkages are needed. The vowel *a* forms one of the best illustrations of this. Not only may this symbol stand for a wide variety of sounds as in *ale*, *senate*, *care*, *am*, *final*, *arm*, *ask*, and *sofa*,[2] but one of its sounds ā may be represented by *a*, *e*, *ey*, *ay*, *ai*, *ea*, *eigh*, etc. In reading, a fair approximation of the exact sound is often quite adequate for the

[2] This list is taken from the Collegiate Abridgment of Webster's New International Dictionary.

recognition of words. In my experience with retraining drills for the correction of the reading disability I find three sounds for the letter *a* are usually sufficient. These are sounds which this letter represents in the three words *hat*, *face* and *arm*. This illustrates the wide difference in the complexity of associations required for reading and for spelling and explains, I believe, why a disability may persist in spelling after reading is mastered. Difficulty with the vowels may result in their complete elision as when *work up* is spelled as *wrkp* and *express* as *xprs*, or in the omission of the muted or unstressed vowels as in *favor* spelled as *favr*, *summer* as *sumr*, and *comfort* as *comfrt*. It may produce substitutions between vowels whose sounds in common usage are conflicting, as where *e* acquires the short *u* sound from its common pronounciation in *the* as shown in spelling *elect* as *ulect*. Another source of vowel confusions, when the visual recall is deficient, is found in words where the sound, even by correct usage, might be expressed by either of two vowels as when *warm* is spelled as *worm*, *afraid* as *ufrad*, *ball* as *boll*, etc. Where simple sounds are represented by diphthongs or phonograms errors are fairly common, as in *sope* for *soap*, *sup* for *soup*, *fit* for *fight*, etc.

Other examples of vowel errors of various types are:

actor	acter	cellar	celler
blossom	blossam	another	unother
elect	ealkt	visitor	visiter
church	chirch	guides	gides
illustrate	elistrate	merchant	merchent
husband	husben	say	sae
aroma	eroma	custom	costum
eight	eaght	costume	custom

While vowel errors are much more frequent in misspellings than errors in consonant sounds the latter often occur and this seems to be particularly true of those children who have been taught in schools which stress the "sight" or "flash" method of teaching reading with more or less neglect of training in phonetics. Such confusions are to be seen occasionally in young children, apparently because of vague similarities of form other than those explained by static reversal. Mistakes of *h* and *k*, *m* and *n*, and *h*

and *b* are probably of this origin. These seem to be comparatively unimportant, however. Confusions are more frequent between two letters representing somewhat similar sounds. Thus *k* and *g* are often mixed, leading to the spelling of *think* as *thing* and *thankful* as *thangful*. The hard (or *k*) sound of *c* is likewise mixed with *g* giving *cown* for *gown*, *croup* for *group*, and *gomming* for *coming*. *D* and *t* are confused resulting in *trawn* for *drawn* and *breat* for *bread*. *V* and *f* form another difficult pair and their interchange results in spelling *vavorite* for *favorite* and, in the reverse order, *abofe*, for *above*, and, for complete security, *half* is written as *havf*. *X* is another letter that frequently makes trouble when its phonetic equivalent *ks* is not known. Very often the *x* represents only a *k* sound to the child and an additional symbol must be used to bring in the *s* sound. Thus we find *express* spelled as *exsprs* and *examination* as *exzamination*.

The *w* and *wh* sounds are frequent stumbling blocks and one twelve-year old boy has accomplished a certain linguistic economy by reducing both *weather* and *whether* to *wether*. The sound of *w* is often taught as *oo* and the child is instructed to pronounce *went* as *ooent*. This linkage sometimes becomes fixed with the resultant spelling of *school* as *skwl*, and *suit* as *swt*, etc.

Occasionally multiple false associations may be built. One boy when shown a *j* and asked to give its sound, responded somewhat hesitatingly with *jŭ*. He had, however, written *began* as *bejan* so I asked him whether "j" might have any other sound in order to see if it were also linked with the hard or gutteral *g*. He answered, unexpectedly, "Yes, pŭ." Further analysis revealed a loose linkage between *j* and *g* based on sound similarity, between *g* and *q* based on a visual similarity in the manuscript writing which he had been taught and between *q* and *p* by static reversal. The result was that any of these four letters when encountered in reading might bring to him either its own sound or that of any of the others, and in written spelling the sound of any one might recall the proper graphic symbol or that of any of the other three.

When the early teaching of reading has been exclusively by the "sight" method to the complete neglect of phonetic training, children with even a relatively mild degree of strephosymbolic

confusion may fail entirely to learn that a sound may be represented by a single letter and will fall back on the nearest whole word to express that sound. These errors I have designated as "sight implants." Thus, such a boy who did not know the sound of the letter *u* but had been taught to recognize the word *you* made quite correct application of what he had been taught in spelling *document* as *dockyoument*. Other examples of these "sight implants" from my records are:

taxation	tacksaytion	education	egyoucation
appal	abhaul	plagiarize	playjurise
appal	apaul	theivish	thevefish
example	exsampull	frequently	freakwently

Some children seem particularly prone to substitute a whole word with a somewhat similar configuration for the one given. Examples of this are:

suit	shout	soap	shop
walk	work	fight	faith
walk	wake	eight	night

Poor visual recall of the letters in words not only limits spelling to a phonetic basis but interferes with the natural aid to pronunciation which comes from a knowledge of how a word is spelled and habitual mispronunciations in their turn may be carried over into spelling with resulting errors which are quite exact phonetic reproductions of the incorrectly spoken words. Thus one of my patients spells *lonesome* as *losome* and pronounces it so. Another, a boy of seventeen, talks of the "*sopperntendant*" of his school and spells it so. Other examples of spelling which seemed to be exact phonetic equivalents of the way the word was pronounced are: *speculating* as *specalatin*, *gyroscope* as *garowscope* and *dangerous* as *dangerss*. Not infrequently the spelling of a word quite accurately reflects common errors of pronunciation, as *libury* for for *library*, *pixure* for *picture*, *easly* for *easily*, and *telphone* for *telephone*. The effects of vernacular pronunciations are also to be seen at times in spelling. Thus it is not surprising to find Boston boys writing *invertation*, *estermate*, *celerbration*, *intervidual*, *perculiar*, and *bananer*.

As might be expected, omissions of letter groups, other than

the dropping of muted vowels as discussed above, are frequent. They seem to be particularly common in written spelling when the act of writing is very slow and laborious. Additions are also encountered frequently, chiefly in the younger children.

A rarer form of error in spelling, encountered somewhat more frequently in reading, is apparently the result of a perseveration of parts of a previous word in the production of a following word of a series. An example of this is *afraid* spelled as *afraight* immediately after spelling *eight* correctly.

When various intermixtures of the errors listed above occur in one word the analysis of the sources of the mistakes is often quite intriguing. In a written composition of a ten-year old girl is found the word *wart* in a context which makes it seem to be a word substitution. However *water* would fit perfectly and later in the same composition *water* is spelled *watr*. *Wart* is obviously *water* with an elision of the second vowel and a kinetic reversal of the *t* and *r*. *Nuls* is a phonetic contraction of *unless* with a kinetic reversal of the *u* and *n*. *Qulkey* is the result of omissions and a kinetic reversal in *quickly*. *Stashne* is a phonetic spelling of *station* with a kinetic reversal of the last two letters. *Appear* by a phonetic contraction and a kinetic reversal becomes *apre*. *Beng* results from an omission and kinetic reversal of *began*. *Blo* is the result of a vowel error and kinetic reversal of *ball*. *Stut* may be constructed from *suit* by an omission and an "in and out" reversal. *Direct* becomes *draxt* when the slurred *i* is dropped and the *e* and *a*, and the *c* and *x* sounds interchanged. The child who wrote this when shown a printed *x* and asked its sound responded, "*ĕk*," and there was practically no difference between her sounds for short *a* and short *e*. *Thol* was offered by a girl of ten for *fell*. She proved to have a confusion between the *f* and *th* sounds and to have associated *e* with a short *u* sound, probably from her pronunciation of *the* as *thŭ* and this was in turn mixed with the short sound of *o*. A comparison between the sentence or word dictated and the written response is often quite essential to the interpretation of errors. Such a comparison is shown below:

> "*Heih bi yon lue hte sumr?*"
> "How did you like the summer?"

Several types of errors can be recognized here and a relationship traced between the product and the work attempted but without the guide sentence such interpretation would be impossible. The struggle of an eleven-year old boy with three types of errors is shown graphically in figure 8. In writting *liberty* from dictation he first produced a vowel error (*e* for *i*) and a static reversal of *b*. He saw the reversal, scratched it out and started again. This time he corrected the reversal but entered another vowel error (*a* for *e*) and a kinetic reversal of the *rt*. Again he saw the

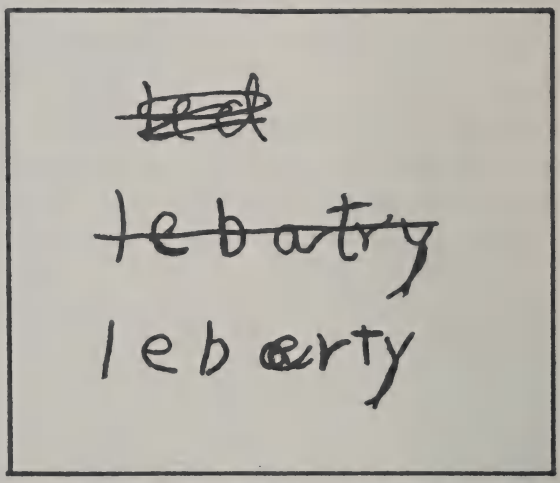

FIG. 8. FACSIMILE OF THE EFFORTS OF AN ELEVEN-YEAR OLD BOY IN WRITING *liberty*
Explained in the text

reversal and struck out the word. His third attempt contained only the two vowel errors one of which he saw and corrected by writing an *e* over the *a*.

As in some of the examples interpreted above, the word written may bear so little relation to the one dictated that it justifies the characterization of a neographism. Examples of these with the words which were dictated are listed below:

propellor.....paloler	ask.....anec
insurance.....inschensche	educational.....eadyouchnall
microscope.....micsiocep	motion.....mothing

century.....	schere	pouches.....	pousesc
scrupulously.....	squpsly	eat.....	etye
enormous.....	enmouse	elect.....	eelkl
ran.....	ralnd	another.....	aghera

Where neographisms constitute the bulk of the written work the product has a bizarre appearance and often is quite unintelligible although it may be legible. Figure 9 is a copy of such a specimen.

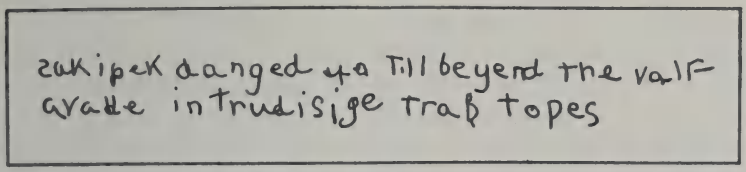

FIG. 9. NEOGRAPHISMS AND MISSPELLINGS PRODUCED BY A TEN-YEAR OLD GIRL WRITING FROM DICTATION THE FOLLOWING SENTENCES: "EXPECT DANGER UNTIL BEYOND THE VALLEY." "AVOID INTRODUCING TRADE TOPICS"

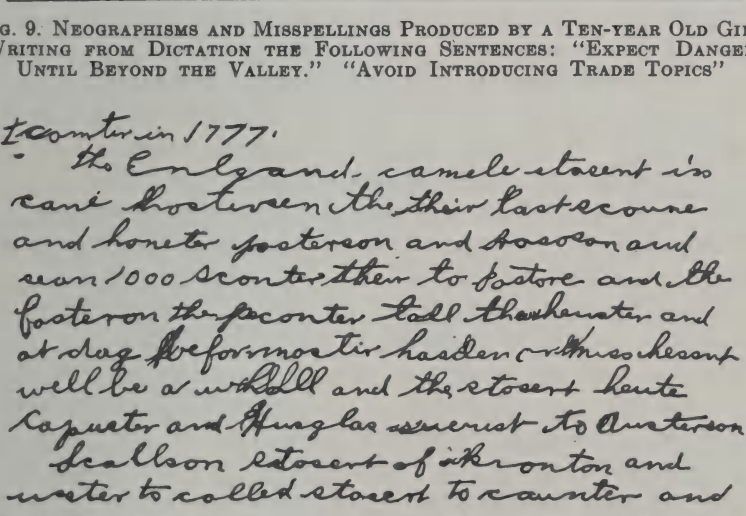

FIG. 10. COMPOSITION IN AMERICAN HISTORY MADE UP ALMOST ENTIRELY OF NEOGRAPHISMS

This was written from dictation by a ten-year old girl who also had a marked reading disability. The sentences dictated to her are given in the legend.

When such neographisms are produced in propositional writing and the content forgotten by the writer an understanding of the words thus misrecorded is quite impossible. This is illustrated

in the "classic" written by a seventeen-year old strephosymbolic, which I have used as an illustration in an earlier article but which is reproduced here (fig. 10) to show misspelling at its best. This is a composition describing the English campaign of 1777 in the American Revolution.

In the foregoing description of symptomatology no effort has been made to construct an exhaustive list of misspellings or to place them in order of frequence or importance since they vary so much from case to case that generalizations are of little value. This bears with equal weight on the question of retraining. No one procedure can be advised for bad spellers in general and re-education must partake of the nature of an individual precription based on a critical analysis of the error types in each case. A series of simple and practical tests to reveal defects is given below together with suggestions for a remedial approach to each. Again no claim is made for completeness and they are intended merely as a record of tests and methods which are in successful use and under trial in current experiments. Many of the tests as well as some of the retraining measures are applicable to disorders of language other than pathological spelling and particularly to the reading disability.

TESTS AND METHODS OF RETRAINING

Tests of auditory acuity should be carried out in all cases where there is any question as to the competence of this function. However, in the great majority of cases it will be easily apparent without special tests that auditory sensitivity is quite adequate.

Rough tests for the accuracy of auditory differentiation of speech sounds may be made by asking the child to repeat the sound of each letter of the alphabet after the examiner. Usually it will be clear that the sounds are accurately reproduced. Where trouble exists a cursory estimate of the relative part played by the sensory and motor fractions can often be reached by repeating the sound as the child gives it and asking if it is correct. For example, one small boy who consistently spoke of his brother as "Wobert" would shake his head in disapproval when I used "Wobert," and would approve only Robert. Clearly the audi-

tory patterns of the *r* sound were correctly registered in his brain and served for recognition but not for control of the motor response. Motor speech difficulties are apt to appear as residuals of infantile speech involved particularly the consonants *r*, *l*, *s*, and *w*. Lack of clear-cut separation of the short sounds of the vowels is often found also. Where these difficulties are revealed the orthodox methods of lip and tongue training in use by speech teachers are recommended.

As a rule the individual letter sounds are well repeated and tests may then be extended to short sound sequences. Here I use both short, one-syllable words and nonsense syllables. The latter would seem, a priori, to be valuable since they exclude the practice effect in known words and they do at times serve to show a lack of clear-cut separation in the enunciation of the sounds of the short vowels which might be missed were familiar words used exclusively. Most children of the special disability group, however, are able to carry out this echo repetition accurately when short units are presented. The words given them to repeat may then be gradually increased in length and as the patterns offered them become progressively larger, difficulty in reproduction becomes obvious. In one recent case, this occurred with a rather abrupt transition when four-syllable words, which were unfamiliar to the child, were attempted and in efforts to repeat still longer words there occurred translocation of the sounds, perseverations, and a few clear-cut verbal reversals. With all single letter sounds and with shorter words and syllables, repetition was practically perfect. No trouble was encountered until the sound sequence became too long to be reproduced by an echolalic type of response, so that registration and recall became necessary for reproduction. Then the difficulty rested on a faulty order of recall. This factor in the auditory function seems to parallel the reversals found in reading and has implications which will be mentioned later. When this type of distortion of words is present I have recommended practice in syllabic dissection of verbally presented long words and their later synthesis from these syllables with care as to order and accuracy of pronunciation.

In all cases of bad spelling as well as poor reading it is important to listen very carefully to the patient's propositional speech for inaccuracies, omissions, and sound confusions. Sometimes this type of error is very hard to detect; for example, in the boy who spells *dangerous* as *dangerss*. This substitution of *ss* for *ous* has been heard a number of times and one must listen with considerable care and attention to recognize it. Clearly a knowledge of how such a word is spelled would aid in correcting the pronunciation but the reverse is equally true—where the spelling is sadly at fault an exact memory of the sounds in a given word will be of aid in spelling it. For this reason, training by the usual methods for accuracy of enunciation is recommended.

The acuity of the visual function, like that of audition, should be carefully examined and refractive errors corrected. As a rule the children with a selective retardation in reading or in spelling will be found to have a normal visual acuity and normal power of visual discrimination. Many of them have far keener vision than others of their school group who have learned to read and spell accurately.

Eye dominance, as well as handedness, is a variable in the bad spellers and should be determined, as a matter of interest, in each case. In the reading disability the right eyed and right handed children far outnumber those with other patterns. In the children who have a selective spelling disability, the left eyed and left handed or left eyed and right handed pattern seems to be somewhat more frequent proportionately than the others but there is no consistency in this. Some children of the sinistral or of the mixed types are excellent in spelling and others who are consistently of the dextral type are poor enough to warrant their inclusion in this special disability.

Tests of the association between letters and sounds should begin with the individual letters of the alphabet. The majority of the older children have learned to give the *name* of each letter on visual presentation of its symbol. Occasionally, however, even the *names* of *b's* and *d's* and *p's* and *q's* will be miscalled and with the younger children and those with the more severe degrees of strephosymbolia there are often quite a number of letters for

which the name is not readily forthcoming. When the child is asked to give the *sound* of each letter instead of its *name*, failures, delayed responses, and confusions are exceedingly common. Occasionally this reveals interesting evidence of former static reversals in that a child may give the correct name for a printed letter and yet give the sound of its mirrored opposite. Thus a boy when shown a printed *b* and asked its name responded promptly with the correct name but when asked how it sounded offered *dŭ*.

Phonetic knowledge of the alphabet is held to be unnecessary by many schools and this may be true for some children but for those who have a tendency toward strephosymbolic confusions it is, I believe, an essential. Training in fundamental phonetics may be carried out to advantage by the usual teaching methods except where confusions of the static reversal type occur. The ordinary process of linking a sound to a printed symbol by repeated exposures fails rather strikingly here, and residual confusions between *b* and *d* may remain in spite of much effort. As in the training of the reading cases, simultaneous tracing over a pattern while saying the name (and alternately the sound) of the letter is recommended to establish the association between the name (and the sound) and the proper orientiation of these reversible figures by means of kinaesthetic reinforcement. This method is often spontaneously adopted by children to differentiate *b* from *d* and they can be seen to try out the direction by finger movements before coming to a decision. Tests for the recognition of *b* and *d*, etc., such as are used in the diagnosis of the reading disability are of very limited value in estimating the part which this confusion plays in spelling since they are selectively measures of recognition rather than of recall. In several instances static reversals of this type have been found to persist in writing long after correct recognition has been established.

The kinetic reversals are of much greater importance in spelling than are the static. These form a factor which comes into play when the sequences of sounds are to be translated into sequences of symbols and may be present to a considerable degree long after the individual letter-sound linkages are correctly established. The presence of kinetic reversals in spelling can be readily recog-

nized but where a tendency toward this is present but masked, and exhibits itself in a confused order of letters rather than in recognizable reversals, it is sometimes of value to test for reversals in reading. For this purpose the test material should be unfamiliar and foreign languages of which the child has no knowledge, may be used to advantage here. Miss Anna Gillingham, psychologist at the Ethical Culture Schools in New York has suggested Esperanto words for this purpose and they have proven very useful. These serve as glorified nonsense syllables and exclude sight recognition and thus test the basic capacity to derive sounds from letter sequences, so necessary in the adequate implantation of newly encountered words. The remedial measures recommended for the correction of kinetic reversals presuppose an adequate grounding in the phonetic equivalents of individual letters, diphthongs, diagraphs and phonograms. When this has been acquired the sequence reversals may be directly approached by training in syllabic synthesis of long words. As an aid to this, following with the finger or pointing with the pencil is to be highly recommended.[3] Its application to oral reading has a definite influence on spelling since it serves to impress the proper order of symbols and to fix the associations between these and the auditory sequences. Practice in oral synthesis of long, unfamiliar words and multisyllabic, nonsense material is also recommended. Letter and word games such as anagrams, cross word puzzles, "ghosts" and "the minister's cat" are often valuable training adjuncts.

In considering spelling errors which appear in writing it is often somewhat difficult to evaluate the motor element. Some help is forthcoming here from the history of the development of

[3] I appreciate that in making this recommendation I am waving the red flag to many educators who hold that it has been statistically "proven" that finger following makes for slow reading. In this I believe there has been a fundamental misinterpretation. I am convinced that the tendency to slow and insecure reading rests on a lack of acquisition of dominance in one hemisphere, that this is determined largely by heredity and that the use of the finger is a spontaneous remedial effort adopted by those who suffer from this difficulty of maintaining direction and as such it is to be encouraged. In simpler words, I believe that these children are not retarded in reading speed because they use their fingers but they use their fingers because they are retarded in reading by direction confusions.

motor skills in the patient, i.e., crawling, walking, running, talking, etc., and from careful historical and observational studies of the handedness pattern of the child. These factors can not be reviewed in detail here. Not infrequently, however, it is possible to show that a child with a history of normal development of the motor functions, a well established handedness pattern, and an average or even superior skill in other manual activities, still has great trouble in the acquisition of writing, and occasionally it appears that insecurity in spelling is the main obstacle. My analysis of the interrelation between spelling and writing is far from complete but some description of the test methods employed will serve to indicate the lines of investigation.

Since the basic process of written spelling in a language using a phonetic alphabet consists in drawing the appropriate symbol for the sound of each letter, the linkages which exist between sounds and their graphic symbols may be advantageously explored. This may be done by dictating the phonetic equivalents of letters to the child and asking him to write the corresponding letter. Pertinent delays and errors are often revealed. The training methods applicable to their correction are obvious. Such direct phonetic training is not of course adequate in English spelling, but certain obvious consonant confusions can often be corrected by practice in writing letters from dictated sounds. Among these mistakes in consonants may be found evidence of static reversals expressed in writing only. The linkages may have been properly established between the visual symbol and its name and its sound and yet a reversal may occur in writing it. Thus a boy when shown a letter *p* was able to give the correct name and the correct sound for it but reproduced it in mirrored form in writing as shown at *3* in figure 7. Comparative tests of the ability to copy in writing and to write from dictation (where the factor of spelling also enters) and spontaneously (where both spelling and constructive effort play a part) are sometimes revealing, i.e., a fairly neat and accurate product when copying and a page covered with erasures, alterations or neographisms when writing from dictation indicates that the spelling of the words rather than the motor element in writing them is at fault. Figure

11 shows such a comparison. Here it is obvious that the remedial attack should be directed primarily at spelling.

In writing, however, the kinaesthetic component is of prime importance and it is quite conceivable that an interference with the written reproduction of words might rest on an inadequate integration of the kinaesthetic patterns with those of audition and vision. This would seem to be the case with those children whose oral spelling is very much better than their written spelling. One outstanding example of this was the case of a girl who had led her class in spelling in Texas but on moving to another state was fail-

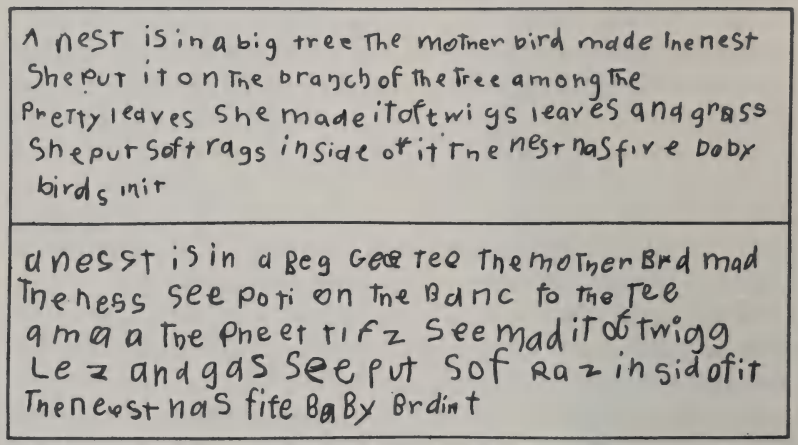

FIG. 11. COMPARISON BETWEEN COPYING (ABOVE) AND WRITING THE SAME MATERIAL FROM DICTATION (BELOW)

ing consistently in this subject. Inquiry revealed that in Texas the spelling exercises were oral while in her new home each day's list of words had to be written. In many schools of today oral spelling has been largely abandoned. Apparently this rests on the assumption that if a child knows how to spell a word he can also write it. This is probably true for the majority but it overlooks the fact that there are many children who vary somewhat from the common pattern in their learning processes and that restriction to a single method of teaching is apt to work a hardship on them. Moreover the two processes—oral and written spell-

ing—employ widely different nervous mechanisms and we would expect to find differences in facility in these functions such as our cases seem to present. Where there is a markedly greater facility in oral than in written spelling the fundamental linkages between individual sounds and kinaesthetic letter patterns should first be examined as outlined above. After the correction of such errors as are found the child will frequently improve very rapidly if taught to spell aloud while writing.

The methods of retraining outlined above are most applicable to younger children. With the older ones there is usually some resistance to going back to lessons in the alphabet for example. In such cases oral reading with attention to the accuracy of enunciation has been found to be of great value. Reading aloud is usually quite difficult and often is exceedingly faulty with bad spellers. This is especially true with those who have been taught to read exclusively by the "sight" or "flash" method. Very often indeed a child so taught has literally no equipment with which to approach the sounding of a newly encountered English word or the strange letter combinations of the test material except for large letter groups such as have been quoted above in discussing "sight implants." His stumbling efforts at pronouncing long and unfamiliar words bring to light the inadequate associations between the "look" of a word and its sound. Reading aloud to a teacher, parent, or tutor who has a good ear for pronunciation and who is alert to the importance of slight variations from accurate sounding is a very valuable training method. The teacher should follow the text by eye in order to assure the reading of every word and to correct misreadings. If this be not done word substitution such as *house* for *home*, *syrup* for *sugar*, *place* for *palace*, etc., may occur without disturbing the meaning of a sentence sufficiently to be noted by the listener. In this oral reading, stress by overpronunciation should be laid on the sounding of all of the letters in a word. Thus *favor* is read with an over emphasized *or* as *favOR*, *husband* as *husBAND*, *library* as *libRARY* and *picture* as *picTURE*. This stress on the muted sounds of words is apt to seem stilted at first and may require some coaxing to accomplish. As one boy remarked, "That sounds awful high hat." Very

little of it is carried over into ordinary speech, however, and the child soon learns that such emphasis serves to fix certain letters in his memory. Care must be taken that the proper pronunciation or its purposely overstressed exaggeration be kept in linkage with the meaning which often has attached itself to a somewhat or entirely different sound equivalent. *FavOR*, for example, must not be planted as a new word but must be built into the association already surrounding *favr*. Certain difficult spellings can often be securely implanted in older children who are studying other languages by explaining their origin. Thus *lieutenant*—"the place holder" and *peninsula*—"almost an island"—can be readily fixed with students of French and Latin.

So intimate is the interlinkage between the various functions entering into the language faculty that in addition to specific training to establish the correct associations between sounds and letters any general improvement in skill in reading, speech or writing may be counted upon to lead to an improvement in spelling.

The psychiatric effects of the presence of a disability in spelling except when it is extreme seem to be relatively mild as compared with those which accompany the reading disability. This we would expect from the fact that bad spelling does not form by any means so great an obstacle to education as does poor reading and errors in spelling are largely condoned. Some children show moderate degrees of inferiority reaction. With many, however, there results merely a disinclination toward writing which may serve as an obstacle to the development of a real facility of expression. Because there is less punishment inherent in spelling failures than in poor reading there is usually not the same incentive to work toward its correction, although usually the children have labored hard enough in school at the task of rôte memorizing of words to be ready and willing to apply themselves to other methods of procedure. They very commonly become much interested in the testing program and in the explanation of their errors and often are quite convinced of the pertinence of the recommendations for retraining. When this occurs they are most coöperative and as they begin to note improvement they often take a very active interest in their retraining and often apply its principles for themselves.

In the review of the subject of pathological spelling, attention had centered, as in previous studies in reading, on the process of building associations between visual, auditory, and kinesthetic engrams. These studies have led to the opinion that the chief obstacle to the ready formation of the proper associations is an inconstancy of recall of the previously implanted engrams with which a sensory experience must be compared in order to permit recognition and, further, that this inconstancy rests on the failure to establish the usual pattern of complete unilateral cerebral dominance.

The dominance problem is pertinent to all expressions of the language function. In written language (reading and writing) the factors concerned are spatial, i.e., it is the spatial orientations and spatial sequences which are subject to confusions such as we see in the two types of reversals. In spoken language (verbal understanding and speech) the sequences are temporal rather than spatial. Traces of confusion in temporal sequence of sounds have been observed a number of times in these studies. One such instance is mentioned in this report. Confusions of sequence in the recall of auditory engrams might quite conceivably lead to an obstacle to the recognition of the spoken word and to its reproduction in speech. Thus fators comparable to those which underlie the selective disabilities in reading and spelling may also operate in congenital word deafness and retarded speech. The challenging implications of this possible extension of the concept of strephosymbolia into the auditory field have led to the establishment, under the direction of the writer, of a research project supported by a grant from the Committee on Research and Publication of the Neurological Institute. This program has already been started with an intensive study of a case of congenital word deafness.

SUMMARY

Selective disability in spelling usually accompanies the reading disability. It may however exist as an isolated defect.

Inconstancy of recall of visual, auditory, and kinesthetic engrams probably interferes with the establishment of the fixed associations needed for correct spelling.

Faulty spelling like other expressions of a language defect is found in certain families in association with left handedness, reading disability, and speech disorders and is considered to be the result of variations in the establishment of unilateral cerebral dominance.

Analytical tests and retraining methods are discussed.

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(2) Orton, S. T.: "Word-blindness" in school children. Arch. Neurol. and Psychiat., November, 1925, xiv, 581–615.

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SPECIAL DISABILITY IN WRITING[1]

SAMUEL T. ORTON, M.D., AND ANNA GILLINGHAM, M.A.

Writing, like other fractions of the language faculty, is intimately related to the problem of unilateral cerebral dominance since it is frequently lost in the adult as a result of destructive lesions of the dominant hemisphere and is not disturbed by lesions of comparable extent and locus in the subjugate hemisphere.

Previous communications by one of us[2] have offered the hypothesis that failure to acquire the usual cerebral pattern of the adult, i.e., unilateral dominance, lies at the bottom of the selective retardation in learning to read occurring in children who are otherwise able, and studies of children who have unusual difficulty in learning to write offer an additional approach to this problem.

Although there are published standards for judging writing quality, its exact evaluation is difficult if indeed not impossible. The factors of appearance or "style" and of legibility can not be rated with accuracy and only that of writing speed can be numerically compared with the product of others and for this reason no exact statement can be made concerning the limits within which the term "special disability in writing" can be said to apply. We have come to use the term for those children who, in spite of adequate or even extensive training, are lagging far behind their accomplishment in other academic lines in learning to write, with average speed for their age, in a legible, reasonably well formed hand. Figure 1 gives the educational profile of such a case. It is not quite pure since this boy's spelling was also somewhat behind his achievement in his other studies but this was making him relatively little trouble in school while

[1] This report is based in part on work done under a grant from the Committee on Research and Publication of the Neurological Institute of New York.

[2] Orton, S. T., "Word Blindness" in School Children, Archives of Neurology and Psychiatry, November, 1925, **14**: 581–615, and other papers.

his writing speed (circa 40 letters per minute) was so low as to form an almost insuperable obstacle in written examinations and in the taking of notes on class assignments, etc.

When a child is first learning to write, distortions both of form and orientation of the letters are very frequent in his efforts. One of common occurrence is that of mirror writing. Occasional reversed letters are so frequent at this stage as to be almost universal. The consistent sinistrad orientation of all letters and sinistrad progression in words, i.e., true mirror writing, is far less common but by no means rare. When this occurs in a left

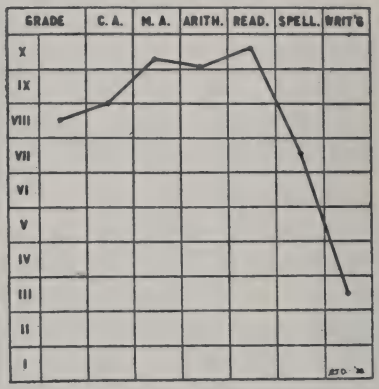

FIG. 1. EDUCATIONAL PROFILE OF A FIFTEEN-YEAR-OLD BOY WITH A MARKED WRITING DISABILITY

C.A., chronological age; M.A., mental age

handed child writing with the left hand it probably represents merely the natural reversal of pattern which results from the antitropism of the two sides of the body and is not considered to be of much moment. When, however, mirror writing is spontaneously produced by the *right* hand, it suggests a twist in reproduction of considerable interest and probably of some prognostic value as most children whom we have seen who have exhibited this initial tendency have experienced considerable difficulty with reading later. Occasionally a vertical inversion is also seen so that the child writes all letters upside down, and

rarely both inversion and mirror writing are combined. As a rule the inversions are rapidly corrected either spontaneously or under guidance but the tendency to reversals is much more difficult to eradicate. These earlier aberrations are not of course to be looked upon as writing disabilities although they do, we believe, indicate certain tendencies which may in some cases persist sufficiently to interfere with the easy acquisition of a writing skill.

Among the older children who have been exposed to training in writing for several years and yet who have made very indifferent progress in it, several groups may be recognized.

The first group is that in which there is clinical evidence of damage or injury to the pyramidal or prepyramidal motor systems. Here are to be found particularly the dystonias of the "birth injury" type, spasticity of Little's disease, etc. In these cases the difficulty in writing is to be looked upon chiefly as an expression of the general motor dysintegration although the question of establishment of normal dominance in these injured brains is far from settled. This is notably so when we consider the problem of an apraxic factor dependent on damage of the thalamus or the posterior limb of the internal capsule or the postcentral cortical fields and accompanying a more overt motor lesion. An extensive series of autopsy studies of such cases will be required to evaluate this factor. In general, however, the difficulty in learning to write experienced by these children is so in harmony with the rest of the motor dysfunction that it need not detain us here.

The second group is made up of certain obvious sinistrals who have met difficulty because of training unsuited to their needs. Of these there are two types: first, those who have been permitted to use their left hands in writing but who have been trained with the paper in the right hand position or have been forced to acquire a slant which is abnormal for them, and, second, those who have been taught to write with their right hands but who have been permitted to retain the use of the left hand in all other activities and who show little or no evidence on examination of confused or mixed dominance. The first group will be dis-

cussed more in detail in the section of this paper dealing with retraining. The second may well be further elaborated here. The large number of left handed individuals who have acquired a satisfactory writing with the right hand demonstrates without question that this is possible in many instances but certain cases seem to indicate clearly that in some individuals the use of the

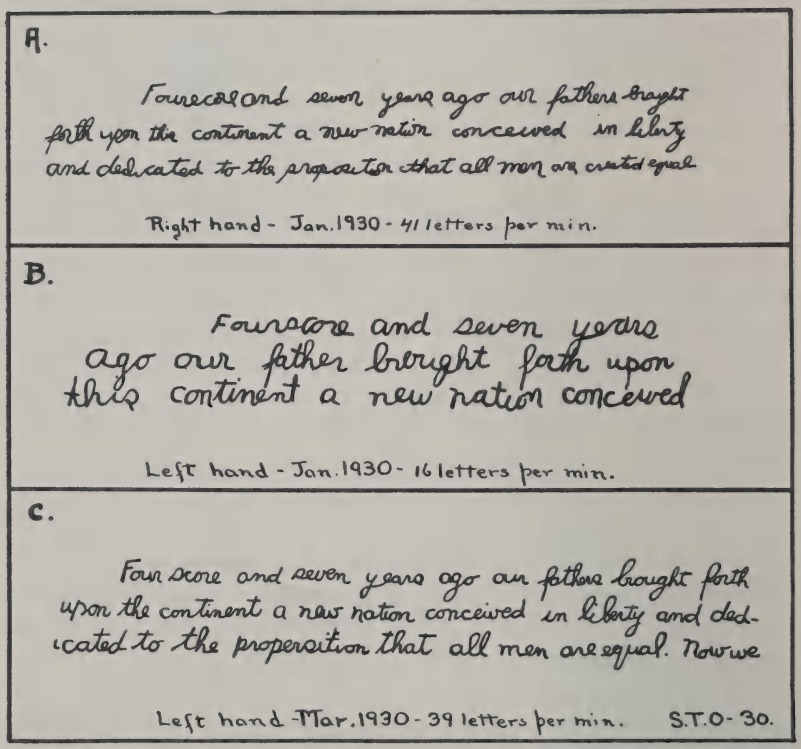

FIG. 2. THREE SAMPLES OF THE WRITING OF A LEFT HANDED BOY OF FIFTEEN WHO HAD BEEN TAUGHT TO USE HIS RIGHT HAND FOR WRITING

wrong hand will lead to serious difficulties. One such case is that of the boy whose educational profile is shown in figure 1. He was recognized from infancy as being strongly left handed but he had been trained to use his right hand for both eating and writing. As he went forward in school his difficulty in learning to write legibly and with acceptable speed became an increasing

handicap so that by the time he had reached the eighth grade, as shown in figure 1, his writing speed had progressed only to the normal rate for third grade children. Figure 2 shows at *A* a sample of this boy's right hand writing at this time. At *B* is a tracing of his product with his left hand in a trial at the same time. As will be noted, the latter, without previous training, is better formed than that of the right. It was, however, only about one-third as fast. In spite of the years of training of the

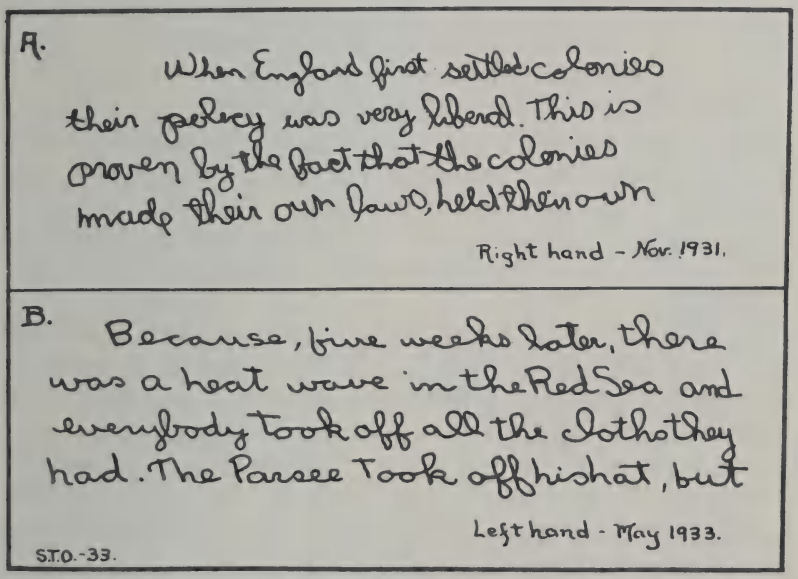

FIG. 3. IMPROVEMENT IN WRITING RESULTANT ON RETRAINING THE MASTER HAND (LEFT) IN A BOY OF THIRTEEN

right, it was recommended that he be taught to use his left hand for writing and within three months as shown at *C* he had acquired a speed with the left practically equal to that previously attained with the right and a much better quality. Figure 3 gives another example of this. This is taken from the work of a left handed boy of superior mental ability, thirteen years of age, who was forced by his school to use his right hand during the first six grades. Near the end of the sixth grade training of the left

was instituted but with insufficient time to establish a facility, and in the seventh grade due to pressure of work he shifted back to the more experienced hand because of its greater speed. In the eighth grade because of persistent poor writing, left handed training was revived and he was given many hours of practice. At *A* in the figure is shown his right hand writing when in the seventh grade while at *B* is shown the improvement accomplished in a year and a half of practice with the left hand. Other cases of this type indicate that while a true writing disability may not result from an enforced use of the less skillful hand, such training may in many instances lead to a much greater difficulty in writing and a much less legible product than probably would have resulted had the master hand been trained for the intricate motor integrations of this fraction of the language function. Occasionally injury or peripheral paralysis of the master hand or arm may dictate training of the other for writing. When this occurs it is wise to bear in mind that writing may be slow and difficult of acquisition and that special methods of training may be highly profitable.

A third and by far the largest group is composed of those children whose difficulty in writing coexists with other problems which we relate to delays or failures in acquisition of clear cut unilateral dominance. These are the cases which we consider to be intergrades between the dextrals and the sinistrals and which, from the results of other studies which will be published later, seem to form a very large group constituting a graded sequence between the pure dextrals and the pure sinistrals.

Several sub-groups may be tentatively segregated under this head, viz.: those associated with strephosymbolia (reading and spelling disabilities), those occurring as a part of the picture of congenital apraxia, those accompanying stuttering, and a group who show none of the above syndromes but do give evidence of confusions or crossed patterns on tests of their handedness and eyedness.[3]

[3] The cases of congenital word deafness which we have studied are omitted here since they are few in number and have not progressed in their education far enough to be judged critically for the presence or absence of a true writing disability.

The association with strephosymbolia is often close. The majority of cases of marked delay in learning to read show a comparable delay in learning to reproduce the letters in writing and with some of these the writing difficulty remains as a more or less isolated disability after a reasonable degree of reading skill has been acquired. The pathological spellers likewise very often suffer from a measure of writing disability. As has been pointed out elsewhere[4] one factor in this may be the great uncertainty in how to spell the word and the consequent distraction from the mechanics of writing. When this is suspected, a test of the

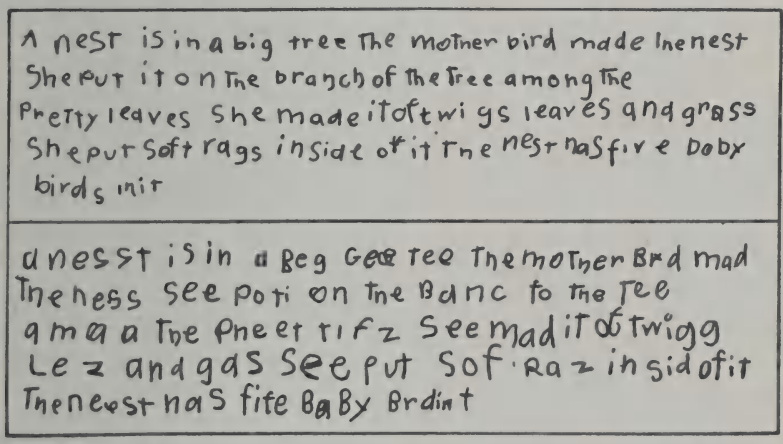

FIG. 4. CONTRAST BETWEEN COPYING AND WRITING TO DICTATION SHOWING THE INFLUENCE OF A SPELLING DISABILITY

child's ability to copy from print into his own handwriting compared with his efforts when writing to dictation or in composition will usually clearly indicate the potence of this element. Figure 4, reprinted from an earlier article, illustrates this. The boy whose work this is, suffered from a considerable degree of strephosymbolia and in this connection it is of particular interest to note the use of the capital B when writing from recall and the correct use of the lower case letter while copying.

[4] Orton, S. T., Special Disabilities in Spelling, Bull. Neurol. Inst. of New York, June, 1931, 1: 159–192.

There is an interesting group of children who in spite of good intelligence and good muscular strength encounter an unusual degree of difficulty in learning any motor patterns which require a high degree of complexity of muscular movements. Such individuals we interpret as cases of congenital apraxia. They usually learn the simpler movements which have a longer phylogenetic ancestry, such as walking, running, grasping, tossing, swimming, etc., with fair skill, although often without much grace, at about the usual age but they are exceedingly slow and clumsy in learning to recombine units of those movements into such activities as dancing, skating, tennis, over hand throwing, sewing, etc. One such child recently studied was a girl of ten with a good intelligence who was competing easily in school with girls older than herself in arithmetic, reading, spelling, and the other academic subjects of her grade but who was left sitting on the mourners' bench when the period for athletics and physical training came around. At home she was a confirmed book-worm and made exceedingly slow progress in skating, riding horse back, tennis, etc., and enjoyed none of them. In many settings this would have carried little penalty but she was unfortunately a member of a family group that valued these activities very highly. On neurological examination she showed no pathological reflexes, no dystonia, and no sensory changes. She did show however marked difficulty and slowness in rapid successive movements, such as repetitive apposition of the thumb and first finger, rapid pronation and supination of the hand, and hopping. She could hop, with difficulty, on the right foot but not on the left. Moreover she was very slow and clumsy in carrying out many practiced movements such as buttoning clothes, opening and closing a safety pin, tying her shoes, etc. It is worthy of note that these difficulties seemed to be of an apraxic rather than of an ataxic nature. Her handwriting, while not pathological, was yet poor enough in contrast with her accomplishment in the rest of her school work to warrant classification as a special writing disability. Her difficulty in this we interpret as a part of the general apraxic disorder.

There is a fairly frequent association of exceedingly poor

handwriting with stuttering, although it is by no means the rule since many stutterers develop a good handwriting. Some of those who both stutter and have trouble in writing are sinistrals who have been taught to write with the right hand and many others are those who give a history of a clearly expressed preference for the left hand in infancy which was "cured" by early and insistent training so that later they, externally at least, appear entirely right handed. It seems probable therefore that many of the bad writers who also stutter should be transferred to our earlier group of those who have encountered trouble due to training unsuited to their particular needs. Exact comparison of the quality of the product in writing is difficult or impossible but as far as our observations go there does not seem to be any special characteristic of the bad writing of stutterers which marks it off from that of other pathological writers. Occasionally their writing shows a certain degree of tremulousness on long strokes but neither the clonic nor the tonic spasms which form so prominent a part of the stuttering episode are as a rule to be observed in their writing. Occasionally we see a considerable amount of movement of the lips—"mouthing of words"—while writing but the motor overflows of this character are by no means so striking as the grimaces of the facial muscles or the even grosser face or body movements which so often accompany stuttering.

The fourth and final sub-group is that of those children who in addition to very poor writing show evidence of intergrading other than strephosymbolia, apraxia, or stuttering. Here we include those who show mixed hand and eye patterns, i.e., right handed and left eyed, or vice versa, those who show variations in a series of tests for eyedness or in the same test at different times, indicating a failure to have established a clear cut choice of a master eye, and those who in their history or by test show that neither hand has developed an exclusive predominance for all skilled acts or who show a decided preference for one hand in spontaneous acts, combined with a greater skill in the other hand for some or all of the motor patterns which have been exposed to the influence of training.

METHODS OF TESTING

As with all the problems of delay in development of the language faculty, the family history is of interest. Occasionally direct heredity (as in the case described below in connection with figure 9) is found. More commonly this is not so but we are becoming increasingly convinced that children with any of these specific delays are much more apt to spring from family stocks in which other evidence of dominance problems can be obtained by careful inquiry. Since the possible relationship of such disorders as bad spelling or stuttering to poor penmanship is not an obvious one, this information can usually be obtained only by direct questioning. For this purpose, queries should be directed toward the existence in the family of left handedness, ambidexterity, reading disabilities, speech delays and disturbances, apraxic disorders, and pathological spelling, as well as of other cases of bad writing.

Obviously the problem of whether the right or left hand should be used for writing is of fundamental importance in the individual case and in determining this the personal history of the patient is often of great value. Inquiry should be made of the parents concerning tendencies noticed in infancy or early childhood toward selective use of either hand and toward a possible prolonged period of indifferent use of both. Questions should also be asked as to whether training was specifically directed toward one side (almost invariably the right in such cases) and if so how much pressure was used and how long it was continued. Similarly, the child's training at school in this respect must be determined. The examiner should also inquire from the patient as to which hand is used by preference in a large range of activities—too small a group may easily prove misleading. Tests for handedness skills are also strongly indicated since frequently training will have resulted in habituation so that the natural latent skills are obscured. Figure 5 gives a good example of this. This was a boy of eleven who had been shifted in infancy from a well expressed tendency to use the left hand and at the time he entered school was looked upon as entirely right handed. He used his right hand in throwing, eating, writing, and most other

trained acts although in many simpler movements he volunteered the left. He was definitely left eyed and in simultaneous blindfold writing with both hands the left gave much the firmer and

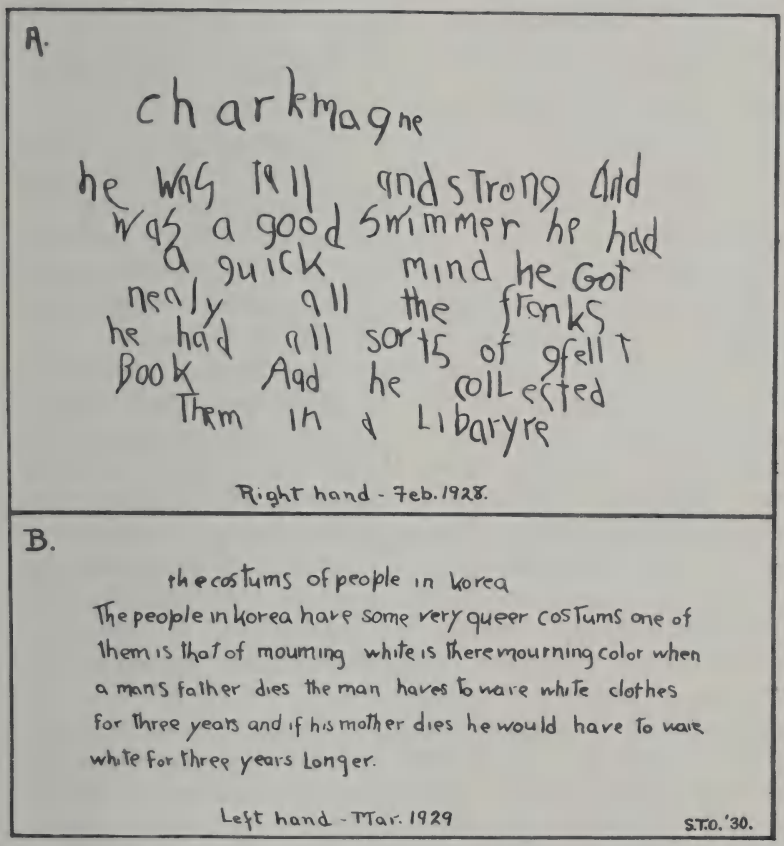

FIG. 5. SERIOUS WRITING OBSTACLE DUE TO MISTRAINING

Sample at *A* was after five years of intensive effort with the right hand in a boy of eleven. *B* shows the result of one year's retraining of the left.

better formed product. He also was a moderate stutterer, a pathological speller, and writing was said to be beyond him after extended drill. On the basis of this and other evidence, retrain-

ing of the left hand was recommended. Figure 5 shows at *A* the skill he had acquired in writing after five years of labor with the right hand and at *B* the result of one year's training of the left. No attempt will be made here to describe the tests we use for either handedness or eyedness since these will form the basis of later reports but it may be well to emphasize that a large number of such tests are advisable since the findings by one method are not infrequently contradictory to those of another.

To determine writing speed we use the standardized "Gettysburg Edition" of the Ayres Scale for Measuring Handwriting except that we present it as a typewritten copy rather than the script as in the original test since many of our patients have considerably greater difficulty in reading script than in reading print. This is especially true of those children who have been taught manuscript writing and have had little experience in reading cursive script. We occasionally further modify the original plan in the case of younger children by giving them much simpler material to copy. Copying is the best test of the simple mechanics of writing since it excludes the distraction due to spelling which is present in writing to dictation and in composition, and also the propositional element in composing. It seems wise however to obtain samples of all three—copying, writing to dictation, and original composition—since one frequently finds a pertinent difference between the writing speed in these tasks and occasionally a somewhat comparable deviation in the writing quality (e.g., fig. 4).

Our studies have not concerned themselves greatly with the question of the quality of writing as estimated by measuring scales but certain obvious faults have been observed in children who have been slow in learning this function. These are chiefly gross crudities in letter forms leading to confusions such as those between *o* and *a*, *b* and *f*, *m* and *n*, etc., marked irregularity in height, depth, or width of letters and especially of the loops, tremulousness, angular distortions of sweeping curves, and marked variability in the slant of the axes of letters. A lack of precise motor control may also show in the numbers of blots with ink or erasures with pencil, and faults in the general distribution

of the material on the page so that spacing of words and paragraphs is apt to be poor.

One interesting exploratory test is to ask the child to write his name or some familiar material such as "United States of America" with each hand in each lateral orientation, i.e., in the dextrad (to the right) direction with first the right and then the left hand and then in the sinistrad (or mirrored) direction with each hand, keeping a record of the time required for each product. For recording, the four specimens may be easily earmarked by the following symbols in which the letter indicates the hand used and the arrow the direction followed: R, L, R, L. It is also an aid to have the mirrored samples written on the back of the test sheet with a sheet of carbon paper face up beneath it, thus reversing on the face of the test sheet the two sinistrad efforts so that they may be more directly compared with the dextrad. A number of interesting observations have been collected by this method. Some children (and some adults) have a rather striking degree of equivalence of all four patterns. Two such instances are shown in figure 6 and are explained in the legend. Our case material is not yet extensive enough to permit of any conclusion from such findings but it is our impression that these children have a good manual dexterity as a rule.

Occasionally the left hand dextrad writing, when first attempted, is of better quality than the right although its speed is less. This is to be seen in figure 2, *A* and *B*. The speed ratio here was R:L::1:3. More commonly the trained hand shows much the better qualitative product but the relative speed may indicate a considerable latent skill in the left. This was the case with a youth of seventeen who came for examination because of stuttering. He was left handed in all spontaneous activities. Figure 7 shows the superiority of his right hand (*A*) over his left hand (*B*) writing. The speed ratio however was R:L::1:2, an unusual relation since the right hand had been trained for writing for eleven years and the left hand had had no training in this function. He also reported a subjective feeling of greater ease in the left hand trial. An experiment in training of the left hand for writing was recommended for its influence

both on speech and on facility in writing and at the end of seven months he had acquired a left hand writing better in both speed and quality than his right as shown at C in the figure.

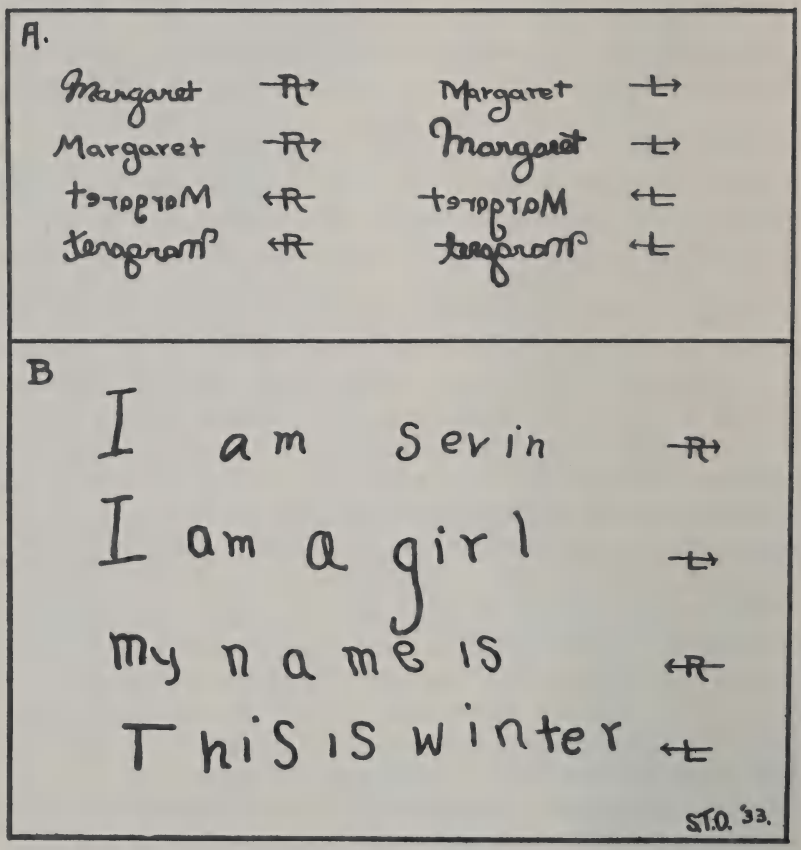

FIG. 6. PRACTICALLY EQUAL SKILL IN ALL FOUR WAYS OF WRITING

At *A* are shown examples in both manuscript and cursive styles. The mirrored samples have not been reversed. The two mirrored samples in *B* have been reversed in reproduction for ease in comparison. The letters indicate the hand used and the arrows the direction of writing.

Not infrequently all four samples are poor (fig. 8). Here again only a tentative opinion is warranted but we feel that the

individuals who give this result are apt to be quite poor in all finer muscular integrations of the hand and may represent the apraxic group.

In a number of cases we have found a marked facility in mirror writing with the right hand in the presence of a striking difficulty with dextrad writing. The most startling case of this sort was that of a twenty-one year old medical student[5] who had never been able to learn to write with sufficient skill to permit him to

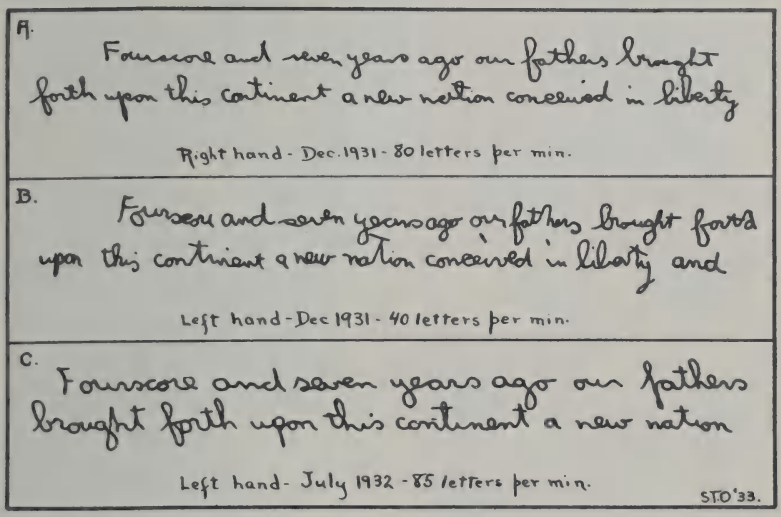

FIG. 7. WRITING SAMPLES OF A LEFT HANDED YOUTH OF SEVENTEEN WHO HAD ALWAYS WRITTEN WITH HIS RIGHT HAND

read his own product unless it was done very slowly and painstakingly. He gave the history that his father had had great difficulty in learning to write and what writing he had acquired was done with the pencil held in a midline position between the two hands and that his paternal uncle, an able lawyer, had found the acquisition of writing an insuperable obstacle. Figure 9 shows at *A* the dextrad writing of this medical student. This

[5] This case has been referred to by Orton, S. T., Hygeia, September, 1927, **5**: 451, and also by Travis, L. E., Arch. Neurol. and Psych., February, 1929, **21**: 386.

was written to dictation and is better than his usual efforts in propositional writing. At *B* is shown his mirror writing with his right hand. This was also written to dictation and was made

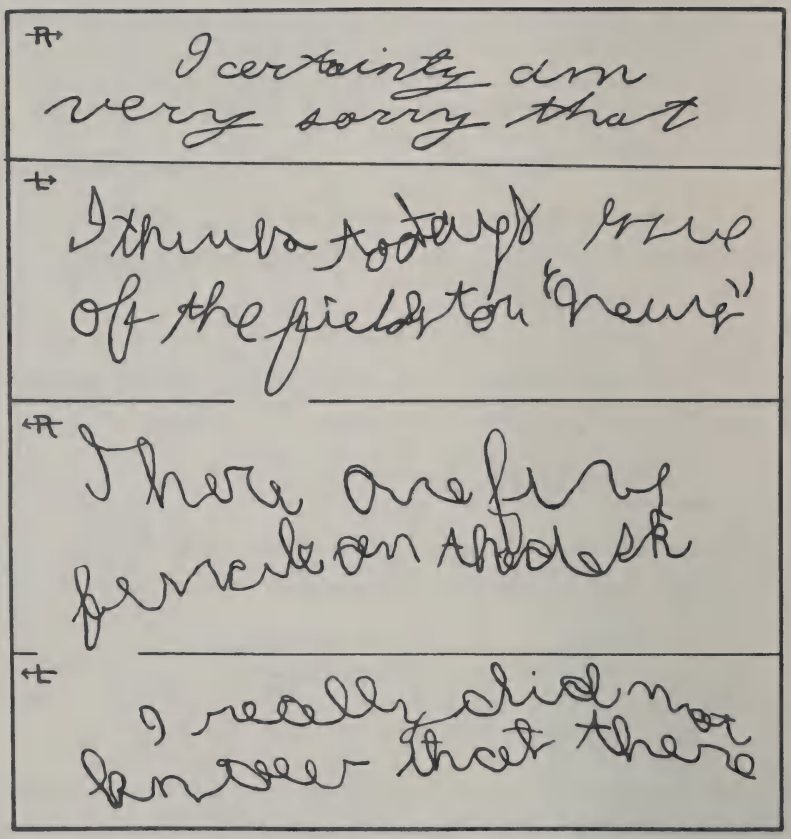

FIG. 8. POOR WRITING IN ALL FOUR WAYS

The mirrored copies have been reversed for reproduction. This was the work of a thirteen-year-old boy with an intelligence quotient of 144.

within a few days after this sinistrad ability had been discovered so it represents an untrained latent skill. He was quite unskillful in writing with his left hand in both the dextrad and sinistrad directions. At *C* is a replica of the mirrored writing reversed by

a tracing process so that its character may be more easily compared with that at *A*. This case was also interesting in that he had acquired a considerable dexterity in other acts. He was interested in bacteriology and was an accomplished technician in this field. Varying degrees of this mirrored skill in the right hand have been found in quite a number of our cases of very poor

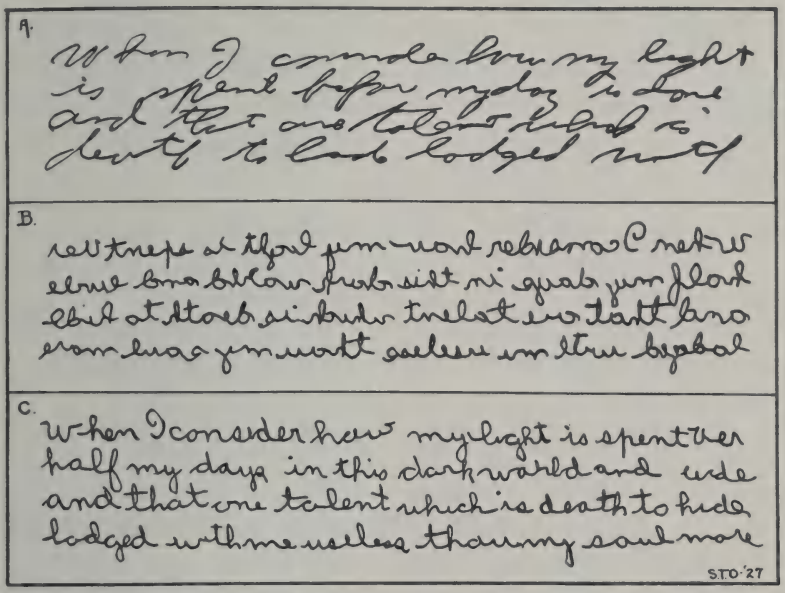

FIG. 9. ALMOST ILLEGIBLE RIGHT HAND DEXTRAD WRITING AS SHOWN AT *A* BUT WITH LATENT MIRRORED SKILL WITH RIGHT HAND AS SHOWN AT *B*

C is *B* reversed for convenience in comparison

writers and another illustration of similar type is shown below in figure 12.

We have found a number of cases in which the left handed mirror writing was the best of all four ways but we have not as yet encountered a case in which the only pattern easily available was the mirrored form produced by the left hand, comparable to the case recorded above, although this is to be anticipated.

Occasionally there is a very striking difference in the super-

ficial appearance of the dextrad writing produced by the two hands due to differences in slant. A good example of this is shown in figure 10. These were made by a college student who was rather markedly left handed although he threw and wrote with his right hand. He reported that in a course in engineering drawing he used the ruling pen with the left hand but changed to the right for lettering. He was strongly left eyed. There was no history of any effort at training the right hand for either the throwing or the writing. His writing was acceptable but it was a

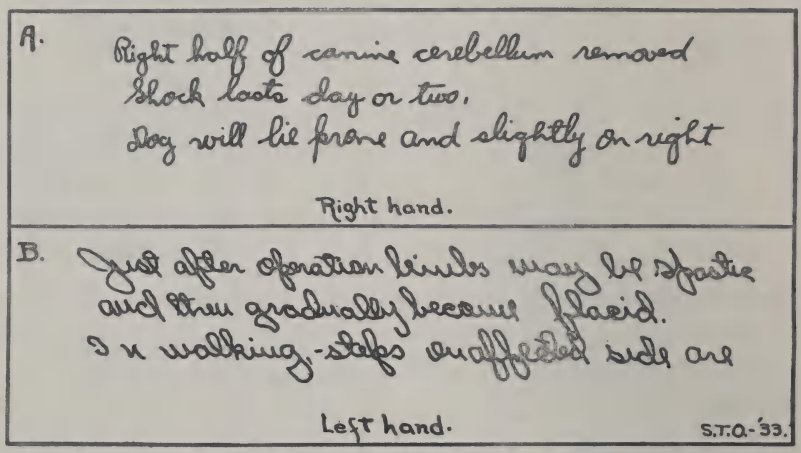

FIG. 10. RIGHT AND LEFT HAND WRITING OF A COLLEGE STUDENT WHO HAD TRAINED BOTH HANDS AND USED THEM ON ALTERNATING SIDES OF THE SHEET IN HIS NOTE-BOOK

somewhat fatiguing process and he felt that he did not do himself justice in written examinations. He was interested in the possibility of developing a more automatic and less fatiguing handwriting by training his master hand (the left) for this purpose and undertook to train himself by copying with his left hand from a printed text for a few minutes daily. A left hand skill developed with surprising rapidity. At *A* in figure 10 is shown a facsimile of his right hand product, while at *B* is that of his left produced after less than a year of training. He had lost none of his former skill with the right and capitalized this double gift by taking

notes in class with the right hand on one side of the sheet in his note-book and with his left on the reverse. The two samples shown in the figure are taken from the two sides of one of these sheets from his note-book.

There is a general tendency for the dextrad writing produced by the left hand to have a backhand slant in contrast to that of the right and the mirrored forms, when well produced, seem more apt also to follow this tendency. There is however no consistent similarity in slant or in form shown between any two or the four types. Frequently the two mirrored forms are much more alike than are the two in the dextrad direction and often both the mirrored patterns tend to be more like the left hand dextrad than like the right hand dextrad, although the comparison is scarcely safe since we are recording here one pattern (i.e., dextrad with the right hand) which has almost always been exposed to considerable training and three which are untrained and hence probably represent a more natural motor pattern.

A test which is somewhat akin to the one last described may be carried out by giving the patient a piece of chalk in each hand and asking him to write his name on the blackboard with both hands simultaneously, with his eyes closed. The most common spontaneous pattern is for both hands to travel together in the dextrad direction (Ꞓ Ꞓ) but it is not uncommon to find the right traveling to the right and the left producing mirror writing (Ꞓ Ꞓ). Much less commonly the left may travel to the right while the right produces mirror writing (Ꞓ Ꞓ) and very occasionally both hands may produce the sinistrad form (Ꞓ Ꞓ). After the spontaneous pattern has been recorded the child may be asked to try the three remaining possible combinations. No definite interpretations are put on the results of this test except that the master hand is apt to produce much stronger and more regular strokes and achieve a much more even spacing of letters even in cases in which the opposite hand has been trained for writing. Confused patterns such as reversals of one or more letters of a series consistently oriented are tentatively considered as evidence of failure to develop a strong unilateral lead. Some children have been found who are entirely unable to write with both hands

at the same time in any of the four combinations and these seem to fall in the apraxic group. The large blackboard writing may be traced for preservation by means of thin tissue paper sheets and a crayon. Caution is indicated in evaluating this blackboard writing in terms of ordinary writing with pen or pencil since it makes use of a very different set of muscular integrations (arm and shoulder vs. hand). Dr. Earl Chesher of the Language Research Project of the Neurological Institute has recently demonstrated in one intergrade a much greater skill in movement of the shoulder group on the left side than on the right but a rever-

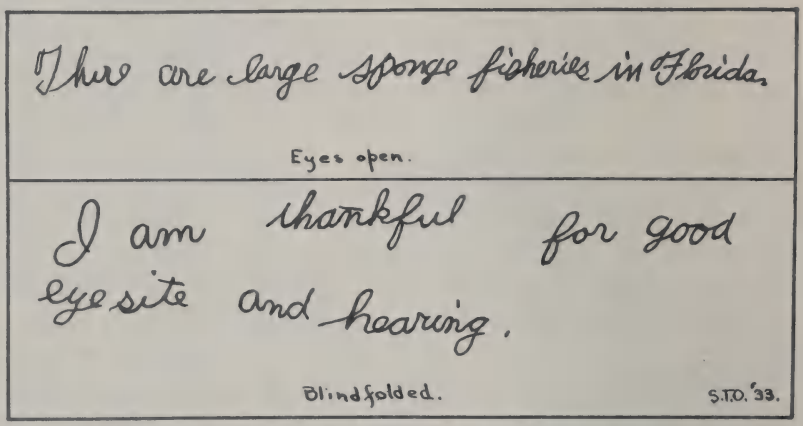

FIG. 11. CONTRAST BETWEEN WRITING WHILE WATCHING PAPER AND WHILE BLINDFOLDED PRODUCED BY A THIRTEEN-YEAR-OLD BOY

sal of this when finer finger movements were tested. This was uncovered by an apparatus of his own designing which is to be described later.

Writing with a pencil while blindfolded is another method of probe which has yielded suggestive results. In this test we have the patient again try writing in all four ways as outlined above. The commonest result is a much poorer product than writing in the accustomed manner, together with comments from the child that it is much harder than with the eyes open. Occasionally a child writes about as well with the blindfold as without except for difficulty in maintaining a horizontal line. The mirrored form

B.

TO DICTATION

His carriage was upright and noble. His presence was dignified and impressive in the highest degree.

C.

TO DICTATION

ere spalt eom ere erelt
.avo'ni ahraq etate berbenrsl

there are more than one hundred state parks in Iowa.

S.T.A.-'32

FIG. 12. AT *A* COPY OF A SKETCH TO INDICATE SKILL WITH PENCIL

At *B* representative sample of right hand dextrad writing. At *C* right hand mirror writing and below this the same reversed. Eleven-year-old-girl.

likewise has been found in an occasional child to be surprisingly well produced with either the left or the right hand or with both. Figure 11 shows a comparison between writing with the eyes open (at *A*) and when blindfolded (at *B*).

As opposed to the above test which aims at testing the importance of the visual factor in writing we have attempted to evaluate the kinaesthetic element in some children by putting the child's hand, carrying a pencil or a stylus, through the passive motions required for the production of certain letters while his eyes are closed or covered and asking him to tell what letter has been traced. In some of the bad writers we have uncovered an almost total inability to recognize such motions.

With many cases a study of the ease of acquisition and the skill attained in fine coördinations of finger movements other than writing will expose a sharp contrast between them and those used for writing. Inquiry will not infrequently reveal a considerable degree of skill in shop work, sewing, drawing, piano playing, etc., entirely out of harmony with the disability in writing. Figure 12 gives an excellent example of this. This was the work of a twelve year old girl who preferred her right hand in all practiced acts although she was definitely left eyed and showed a high degree of equivalence between the two sides in tests of untrained skills. At *A* in the figure is a sketch made by her in her own home showing, we think, an entirely adequate skill in the use of the pencil. At *B* is a representative sample of her dextrad writing. *C* shows her skill in mirror writing with her right hand, which had been tried only a few times before this experiment, and at the bottom of the figure is the mirrored writing reproduced in reverse to permit an easier comparison with the dextrad sample.

DISCUSSION

Clearly the most usual pattern of learning to write is first the establishment of a visual engram of the letter form, then the gradual association of this record with the kinaesthetic engram necessary for its reproduction, and finally a progressively increasing facility of control by the kinaesthetic fraction until the writing process becomes semi-automatic. Intimate associations are

also obviously formed with the auditory engrams, completing the three fold integration pattern which seems to underlie the whole of the language function. That neither the visual nor the auditory fraction is essential to this process is convincingly demonstrated by the fact that Helen Keller has learned to write without the aid of engrams implanted through either the visual or the auditory pathways. Miss Keller has been kind enough to supply an example of her writing for an illustration in this article, which is reproduced in figure 13. The part commonly played by the visual element however, even when writing has been cultivated to the point where it has been invested with well nigh automatic facility, is shown by the almost constant occurrence of agraphia

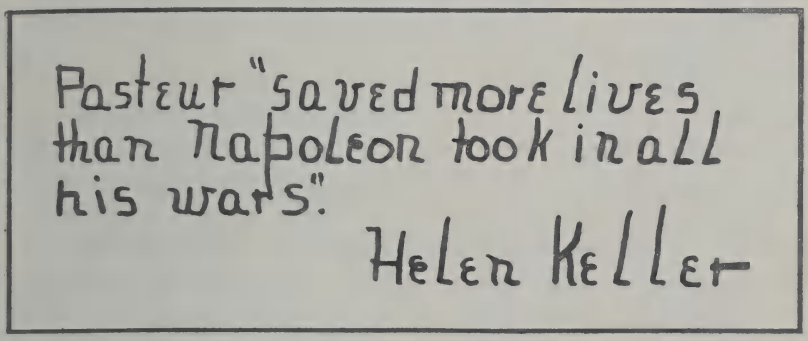

FIG. 13. A SAMPLE OF HELEN KELLER'S WRITING

as an accompaniment of alexia due to lesions in the angular gyrus region and without complicating paralysis or demonstrable kinaesthetic losses.

We have encountered no cases in which we were able to trace the disability in writing to disturbances of the visual implant alone although such cases with uncorrected visual errors undoubtedly exist. In those children who show a striking defect in recognition of the passive movements of tracing letters and in those whose writing trouble is part of a general apraxia but without organic motor symptoms, unusual difficulty in learning to write may be tentatively ascribed to a failure of establishment of the usual kinaesthetic patterns. In the rare cases where blindfold

writing is as good or better than writing with the eyes open the assumption seems justifiable that there has been a failure to establish the normal facile association between the visual and the kinaesthetic engrams, resulting in a measure of conflict. One of our boys who showed this characteristic said of the experiment, "It's easier that way because you don't have to look at the letters." This suggestion of rivalry between the arriving visual sensations and the recall patterns necessary for reproduction was also strongly suggested by our observations in an unreported case of alexia. This man had suffered from a fracture in the left parieto-occipital region. When asked to copy figures he was quite unable to do so while looking at them although he could reproduce them after observing them for a moment and then closing his eyes while he made the copy.

The number of children who are very poor writers and yet have an uncultivated skill in mirror writing is impressive although contrast as great as that shown in figures 9 and 12 is unusual. The existence however of a highly organized though undiscovered sinistrad skill in the presence of a marked dextrad disability seems to add considerable weight to the thesis of interhemispheric rivalry resultant on failure to acquire the complete unilateral pattern of the normal adult. Additional weight is given to this in the two cases quoted above in both of which motor skills below the language level of cortical integration were well developed, since it is at this third level that the problem of unilateral dominance is most securely established.

One obvious result of these studies, which confirms our findings in strephosymbolia and in our studies of handedness, is the conviction that all of these faulty integrative patterns show a very wide variability in both the qualitative and quantitative sense. The highly individual character of the organization of skills and disabilities in a given child emphasizes again the need of full analysis of each case and an approach to treatment without fixed methods but rather as an experiment. It should also be remembered that many normal writers show on test good mirror writing and an occasional one a practical equivalence in all the four ways of the test. The finding of mirror writing or other unexpected

skill therefore in a child can only be interpreted as part of the whole picture and not as a rigid diagnostic sign.

We have no opinion to offer on the debated question of manuscript versus cursive writing except that it is clear that in children who have a native difficulty in establishing the kinaesthetic engrams required for writing, training should be consistent and one method should be maintained. Some of our patients have been changed back and forth from one method to the other with change in school as many as three or four times and have failed to gain an acceptable skill in either or have acquired a "succotash" of letter forms. Figure 14 shows an example of this. The cus-

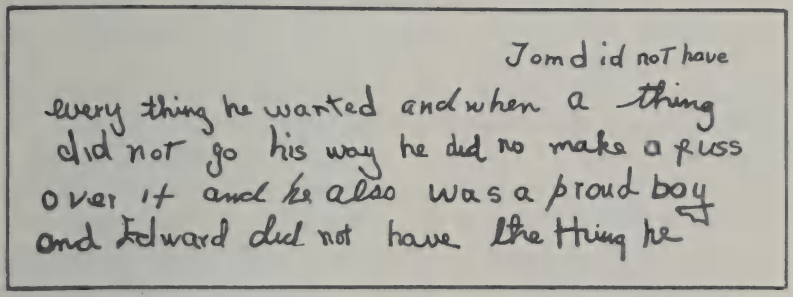
Tom did not have
every thing he wanted and when a thing
did not go his way he did no make a fuss
over it and he also was a proud boy
and Edward did not have the thing he

FIG. 14. MIXTURE OF CURSIVE AND MANUSCRIPT LETTER FORMS

This was produced by a thirteen-year-old girl who was taught in manuscript writing for the first four school grades and then for three years in the cursive.

tom existing in some schools of training in the manuscript style for several years in the lower grades and then starting over with the cursive has been followed in some observed children with almost as much trouble in learning the new forms as they had in the beginning. Indeed mixtures such as that produced in the figure, which are particularly prone to appear when the child is tired or hurried, suggest that the existence of a double set of engrams may in some children serve as an added liability. This is particularly true of children in those schools in which the shift to the cursive writing is required in a certain grade but is not accompanied by adequate training to establish the new forms.

As in all of the special disabilities the emotional factors are of

prime importance in evaluating the severity of the condition and in outlining treatment. As a resultant of the presence of the writing disability we see as a rule much less marked emotional upheavals than those which follow severe strephosymbolia but a considerable measure of a feeling of inferiority is often engendered by a serious failure in writing after conscientious effort has been made which often carries over into other academic work. Conversely a striking improvement in other subjects is not an unusual result of the return of self confidence which comes with successful training. The child's own attitude toward the difficulty and that which he has absorbed at home have a considerable influence on his spontaneous efforts to correct his trouble. Where he has heard that "No business man has to write his own letters," he is not apt to be impressed by the need of learning to write. A very slow penmanship may however form a real obstacle to success in school work as in the case of one of our boys who consistently was able to finish only about one half of his examination questions in the allotted time and was failing in all of his examinations as a result, although his papers were almost perfect as far as he went. This experience gave him a deeply ingrained feeling of hopelessness about the scholastic hurdles ahead of him. Any undue emotional factors operating at home or in school may appear as contributing elements in the disability. This seems to to be particularly true of the type of child who is in need of rather rigorous discipline to encourage much output of effort and who is not receiving this adequately. In other children, the writing disability may serve as a real block to their written verbal expression and may reduce the quality as well as the quantity of their output in written compositions, letters, etc., and engender an emotional bias against all situations in which writing is required.

As with the reading and spelling disabilities, there remains for a long time a tremendous variability in the child's product after the retraining has been undertaken. When such a selective difficulty has existed, apparently the older distorted patterns are still apt to recur after new and correct habits have been established by properly designed retraining so that ground won by patience and persistence may seem to have been completely lost

almost overnight when new emotional or physical stresses arise. One boy who had been making good progress with his writing suffered a broken leg and his mother reported that his writing had gone "all to smash." Such slumps are usually transitory, however, and the lost ground is generally very quickly regained.

The writing disability is much more frequent in boys than in girls. This conforms to findings in other special language delays and suggests a sex influenced hereditary factor. In a series of thirteen children selected because of bad writing from the Ethical Culture Schools, eleven were boys and only two were girls. A direct hereditary history of writing trouble is not common but the frequence of left handedness and of other language disabilities in the families of our cases is significantly high and the disorder is looked upon as one of the variants of the dominance problem resting largely on an hereditary basis.

The much discussed question as to whether it is wise to train a left handed child to write with the right hand can not be answered as a generality with any assurance. Many left handed individuals have been so taught with no obvious ill effects but it can scarcely be gainsaid in the light of some of our material that difficulty may follow both in speech and in writing and there remains moreover the possibility that even those who have escaped complications might have written better and with more ease had their native tendencies been cultivated. Studies along the lines of the examination suggested here would be of interest, for example, in cases of writer's cramp.

TRAINING PROCEDURES

With left handed children who have been trained to write with the right hand and who are failing rather badly to gain speed and legibility with this hand, an experiment in retraining the left hand is justified even though the writing with the left hand is unpromising at first attempts. In this event—as indeed with all left handed writers—the position of the paper and the slant of the letter axes in writing are very important to prevent the awkward positions so often assumed and so difficult to eradicate. The problem of the position of the paper seems so simple that one

wonders at the number of times that left handed children are allowed to hold the paper in the position which is correct for right handed children but not for them. Easy right handed writers usually carry the weight of the arm at the elbow using the internal condyle as a pivot with the paper in such a position that the swing of the forearm from this fixed point will permit the hand to follow across the sheet with a minimal shift of arm or body posture (hunching). The top of the sheet is toward the left and the angle which the paper makes with the mid plane of the body naturally varies somewhat with the individual to permit the hand to traverse the sheet horizontally while pivoting on the

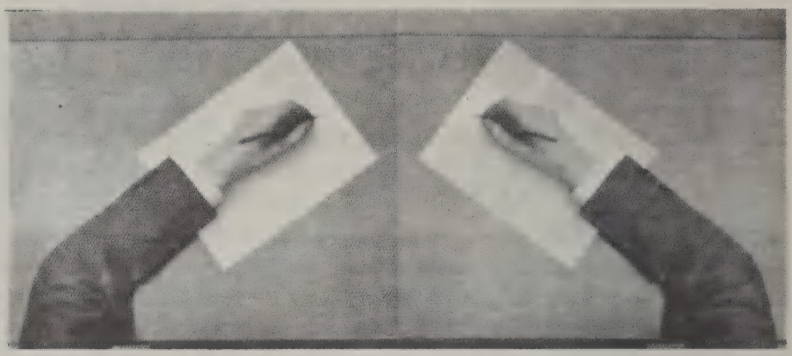

Fig. 15. Photograph to Show a Common Right Hand Position in Writing and Its Exact Left Hand Counterpart

condyle. Obviously, to adapt this position to the left handed person the top of the sheet must be toward the right and the paper must make an angle to the body plane exactly the opposite of that for the right handed person. Figure 15 shows these two positions. In order to make the two halves of the figure exact antitropes they have been produced from a single negative as obverse and reverse prints.

Our experiences in training the bad writers lead us to place emphasis on the need of determining the natural slant of letter axes for each individual. This appears from our present work to be of paramount importance in both right and left handed child-

ren as a preliminary to further training efforts and indeed in some cases the adoption of the natural slant has been the only training factor necessary to produce an almost magical betterment in the penmanship. The backhand slant is generally accepted as the usual pattern for left handed writers but it is not so widely recognized that it may be the facile method for certain right handed people. To ascertain the natural slant, specimens of the child's attempts at writing, especially those toward the end of an assignment when fatigue is beginning to set in, are examined carefully to see whether there is a greater tendency toward one deviation from the vertical than toward the other. Free hand exercises with the eyes closed may also be tried to determine whether lines in any one slant tend to maintain their parallelism better than in others. Pages ruled with parallel lines in the vertical and in exaggerated right and backhand slants are inserted on different days beneath translucent paper and the child is asked to write between them and the product is examined to see which he has followed most closely. It sometimes is necessary to overcome a prejudice derived from previous teachers or from parents before thorough coöperation can be obtained and it is essential to have the child understand that this is an attempt to capitalize native talents which will result in easier and more fluent writing. Even in the face of a strong prejudice most children can be led into trying a new angle for a time "just to see how it will work" and once an improved skill is demonstrable the prejudice usually completely evaporates.

In the younger children and in the older ones with more severe degrees of the disability, training for fixation of proper letter forms is important. For this purpose patterns carefully drawn on coördinate paper and copied by the child on similar paper are advantageous. If this be presented as "drawing," not writing, it often aids by relieving the feeling of need for speed which has usually been engrafted on writing. When the form has been copied a variable number of times, the child may be asked to attempt it again with the eyes closed or looking away from the paper. This training of the motor patterns with the visual sensory element excluded has proven of great value. Indeed this

procedure has formed the mainstay in the successful retraining of a number of cases which had proved obdurate to extended drills in previous years by ordinary methods. The exclusion of the current visual sensory impressions of the work being produced may be accomplished by imposing a barrier between the eyes and the page, or by drawing the letter from memory with the eyes closed or by looking at a pattern on the blackboard at a distance without lowering the eyes to the paper. In some cases we have drilled the child for several weeks by these methods before permitting him to look at the page on which the writing was being done and when this was permitted he was told that it was only for the purpose of following lines and margins and not to direct the pencil by sight. Usually it is easy to obtain free, well formed letters in this way and the cramp in the fingers, the clenched jaws, the "mouthings," and stiff body postures so common to the bad writers often almost immediately disappear. This procedure, as will be seen, is analogous to the "touch method" of teaching typewriting.

With very young children and especially with those who suffer from the not infrequent combination of strephosymbolia or its derivative, the spelling disability, it is doubly advantageous to combine a measure of phonic training with the writing by teaching the child to write the letter from its dictated phonic equivalent (i.e., its "sound" rather than its name) and it is often of further value to have the child repeat the "sound" and at another time, the name, of the letter while he forms it. This double training will aid in establishing the consistent recall of the letter form in one orientation, essential for reading acquisition, and will also serve to prevent the occasional failure of linkage between the sounds of the letters and their proper graphic reproduction which underlies the cases of good oral spellers who make many errors in written spelling. At the beginning of this training, it may prove helpful to have the child trace the letter forms over copies made by the teacher, which will insure the establishment of the kinaesthetic engram in its proper orientation, and similar tracing and sounding of letters combined into syllables and phonetic words will aid the formation of the habit of consistent

progression to the right for both reading and writing. When the word stage is reached, copying from the blackboard or from printed text may be added but it should be remembered that copying is advised in all training for writing rather than writing to dictation or in composition. At first the aim in this should be accuracy and neatness rather than speed and later an increased speed may be encouraged as fast as can be achieved with maintenance of quality.

The retraining lessons are laborious work for the child and it is deemed unwise to make the lesson periods too long. Indeed frequently repeated short periods seem to return a better yield. No statement can be made as to optimum time here since this varies with the age and temperament of the child and with the severity of the disability. With young adults who wish to undertake their own retraining we advise starting with copying for ten minutes daily at first, increasing this as rapidly as possible without inducing undue fatigue until one-half hour per day is reached, maintaining this until a good speed and quality are gained before undertaking propositional writing. Daily practice is highly advisable as even the interruption of the training over a week-end may show itself in a regression to the older patterns when the child returns to school on Monday morning. In those children who have a severe handicap it is important to relieve them from all other writing except that during the retraining period. Otherwise the pressure for speed in class work, examinations, etc., often largely negates the value of the special training. Various provisions may be made to accomplish this. All written work may be omitted, oral examinations may be substituted for written, work to be prepared out of class may be dictated to parent or teacher, or, if the child has learned to use the typewriter this may be substituted for handwriting. We feel it important to stress this point of relief from other writing pressures until a reasonable skill has been gained, as we have seen failures and regressions which we believe to have been directly due to neglect of this precaution. For this reason, the summer vacation period may prove an excellent time for the initiation of the retraining program provided that adequate supervision can be secured.

Above all it is important for the teacher to appreciate that the rebuilding of a facile set of controlling patterns which are not spontaneously forthcoming must be done slowly and that the child must be encouraged continually by pointing out his improvement rather than his mistakes. Our experiments are not yet of long enough standing to evaluate the end results of special training. We feel secure in saying that a legible handwriting can be secured in almost every case but it seems probable that those who have had a marked disability will always carry a measure of the handicap, expressed in lack of ease of writing, in inferior writing speed, or in regressions under pressure for too great speed or in examinations or at times of emotional or physical stress. In this again the writing disability cases are closely akin to the cases of the reading and spelling disabilities.

Finally, in fairness to both child and teacher it must be remembered that this special obstacle may exist as an isolated phenomenon unrelated to the general intelligence or to other academic skills and that to judge such a child solely on his written work will result in an unjust estimate both of the child's acquisitions and of his teachers' success in training him.

SUMMARY

Cases of marked retardation in learning to write are described and discussed.

They are tentatively grouped as cases with predominating motor difficulty, cases largely dependent on an apraxic factor, and cases in which the visuo-kinaesthetic association process is disturbed or retarded.

Except for those cases accompanying demonstrable motor system disease, they are considered to result from failure to establish the adult pattern of unilateral cerebral dominance.

Cases are reported with a persistent difficulty in learning to write in the dextrad direction but with a latent skill in mirror writing with the master hand. These cases show good manual dexterity except in writing and their symptoms are held to be added evidence of interhemispheric rivalry.

Methods of examination and training are described.

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THE DEVELOPMENT OF SPEECH UNDERSTANDING IN RELATION TO INTELLIGENCE

by

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The origin of human speech is lost in the shades of antiquity. We have no very clear idea of the source of human speech as a particular function, but I think there are some things we can derive from biological parallels by studying the situation in animals.

Man is the only speaking animal, but as a matter of fact, all animals have means of communicating with each other; while not speech in the true sense of the word, yet means which do carry from one animal to the other a great deal of the emotional tone of the situation, so that the mother hen has an entirely different cluck for her chicks when she wants to feed them than when she is urging them to hide from the oncoming hawk. Again the dog's tone of voice, so to speak, carries a very different implication if he is on the trail of a rabbit than when he is whining for the favor of his master. There is a great deal that can be communicated by animals to each other in this sense of carrying feeling tones of a situation. The striking difference between human speech and this communication of the animal is that the human has learned to substitute a meaningful word or symbol for the object itself, and that the animals do not have. I say "do not have" advisedly, because we do find that a good many animals can be taught the meaning of certain sounds to serve as symbols. There are many trained dogs that can be sent from one room to the other to get a specific article, e. g., to fetch the master's gloves, and they will not come back with anything but the gloves.

So it is quite possible to train a certain measure of symbolic registration in some of the brighter and more intelligent animals,

but they do not serve as symbols which an animal can reproduce in order to pass on its meaning to others of its own kind. It is only in man that we find true symbolic speech actually developed.

We do not know much as yet about the age of symbolic speech. It has been estimated roughly by anthropologists, largely on the basis of the brain case capacity of fossil man, that the brain was not large enough to serve the function of speech until approximately a half-million years ago. Man had not reached the development in brain size which is required for the handling of language in the human sense until approximately a half-million years ago, and that is a comparatively short geological period when you realize that the mammalian series of animals alone runs back two hundred million years.

Meaningful speech is a thing in which we should have particular interest because it is the function which is exclusively human and is our measure, very largely, of what we know generally as intelligence.

There is, I think, to be seen in every youngster a parallel evolution in the individual to the philogenetic parallel. The infant at first understands keenly the emotional tone of things that are said to it long before it recognizes any of the meanings of the words said. The child knows when the mother is frightened without any knowledge of the meaning of the word which the mother is using. Indeed, the word might be left out entirely and the feeling tone of the voice would carry over the emotional set of the instant without any true meaning whatsoever. I think we can see there an evolution in the beginning of the child's history quite parallel to that of animal speech which we can recognize so clearly in the animals below man's grade.

Gradually this emotional speech is supplanted by meaningful speech as the child learns to recognize or is taught to recognize the meanings of the individual word, thoughts and associations of the word which correspond with the given object or situation or duty or need of the moment. That that is purely a matter of teaching or of conditioning may be readily enough seen by the fact that the child learns the language to which it is exposed. There is nothing inherent in the word or its associated meaning except that which is taught to the child by the parent or teachers who are working with him;

so that the child will learn English, French or Swahili with equal facility, depending on which he hears.

Obviously it is the language itself which is an artificial structure built to indicate certain meanings and which is implanted in the child gradually by experience as he goes forward. The word, when it is learned by the child, rapidly becomes a handle by which that individual child can communicate with others. Almost without exception the child begins with certain nouns, often with the pronouns "I" and "we" in certain types of children, but more commonly with nouns having concrete meanings. Gradually to the learning of the names of objects around him is added the learning of abstract and derived meanings of words which carry so much of the meaning of our ordinary conversation and communication with each other. Indeed, I think one might say that intelligence, as we recognize that intangible and very difficult subject, is merely the soil in which the language function can be grown. There must be a certain degree of ease of adaptability of the individual in order that the language may be implanted there, and the ease with which the language function is picked up by various children is very strikingly variable.

If there be a definite sensory defect of intake and if that defect be obvious, we have a problem which can then be approached through some other sensory pathway. I can never think of defective situations without thinking of what was done in the case of Helen Keller. Deprived of both vision and audition, she was educated in a marvelous manner merely by substituting the sense of touch. Many of us would think immediately that she probably had a highly exaggerated sense of touch. One would think that there must be some kind of compensation where both vision and audition are lost and she would have probably developed the sense of touch above that of others. That has been disproved. My friend and colleague, Dr. Frederick Tilney, has studied Miss Keller's sense of touch critically and found it to be actually below that of the average individual.

Where it is obvious that the child is blind or deaf from the beginning, the problem is not so complex; it is not so hard to understand and not so hard to approach. Fairly adequate institutions have been built up for the handling and special education of both those groups. If, however, the sensory defect is masked and is not so easy to recognize, then the problem

becomes one in which there is much more complexity and it is more difficult to understand what should be done and how to approach it.

The first requirement for the development of spoken language is obviously hearing. If the child be completely deaf the spoken language is going to be strikingly difficult to acquire and can be taught only in such a round-about way as the speech taught to Helen Keller. Yet it is sufficient for her to serve as a means of communication. She has been taught through the kinesthetic pathways how to place her lips and tongue for the sounding of certain vowels and sounds and in that round-about way has been taught to make speech sounds which, though defective, are definitely understandable. It is where there is a clear defect that it is rather easy to understand what we are dealing with. But there are certain other types of sensory defects which are not so clear and which I think we must consider with considerable hesitation before we accept them entirely, but which certainly are open to investigation, and deserve careful further study.

There are two of these types of masked hearing defects which would not be obvious to the superficial examination, which we have been working with in our research laboratories at the Neurological Institute with a great deal of interest. One of these is a type of deafness which is known as "high frequency deafness." We do not like that term "high frequency" because we have found a number of cases in which a comparative defect is found in the lower frequencies of the hearing range rather than in the higher frequencies, but the commonest form is a case in which audition is entirely normal or practically normal for all the lower ranges of sounds which the normal human ear can receive, but in which there is a distinct loss of acuity of reception at the higher frequencies. If that loss is in only the extremely high frequencies, it does not interfere in the least with the speech mechanism. If, however, it happens that the loss in acuity falls between 512 and 2048 double vibrations per second, that field in which most of the human speech sounds fall, the patient will have distinct difficulty in understanding the spoken word and, even more strikingly, difficulty in reproducing it in speech.

I have seen, for example, two little girls, sisters of six years and eight years of age, both of whom had very striking defects in their speech. They had almost no "s," "th," or "f," etc.

They would occasionally get them into a word and some of these sounds they had learned by watching the lips of others. They had become rather proficient lip-readers by themselves.

In studying their audiograms, both of them were found to have a striking loss of hearing in the higher frequencies only. The lower frequencies—ordinary sounds of the environment and deeper sounds—were heard with fair accuracy and yet when it came to the high frequencies, to the pitches of notes which are necessary for the differentiation, e. g., of "s," "th," "f," etc., these children could not hear them and consequently they could not reproduce them.

Finding two youngsters in the same family with the same speech defect, the question immediately arose as to whether or not the younger one was not copying the older one. However, when we finally had their completed audiograms, we found that both had approximately a similar defect. One had a 28% loss within the speech range and the other a 32% loss in the same range. We immediately suspected a family difficulty and so we brought the father and mother in to have their hearing also tested by the audiometer. The mother's hearing was absolutely normal at all frequencies. The father rather pooh-poohed the test and said, "I was in the aviation service overseas in the War and I had my ears extensively tested before I was admitted. There can't be anything wrong with my ears." Each of his ears had been tested largely for the functioning of the semicircular canal rather than from the auditory acuity standpoint and he had never had a selective audiogram of this nature. When we finished his audiogram we found that he had a high-frequency deafness almost exactly like that of his two daughters, except that his was further up in the range of frequencies and had not affected the speech range. His difficulty began at the pitch of 2048 double vibrations per second and from there on up he was partially deaf, whereas with his daughters that same gap occurred lower down the scale so that they missed many sounds spoken to them which were important in understanding spoken words and in reproducing them.

Instead of the term "high frequency" we would rather substitute the term "regional" deafness as a deafness within a certain region of the hearing spectrum. This type of partial deafness or regional deafness does not, as a rule, influence very strikingly the understanding of the spoken word. A child gets enough of the skeleton of the word to attach a meaning to it,

and hence the defect does not interfere with the general intellectual development.

There is, however, another type of deafness which I think is very meaningful indeed, from the standpoint of the development of the intelligence and that is "congenital word deafness," a condition which leads us immediately into deep and pretty largely uncharted waters. We do not really know very much about the story. It is a novel research field and yet a field in which there appears to be so much promise that it seems more than worth while to study it very intensively.

The concept is drawn largely from cases of individuals who have formerly known how to talk and then because of injury or damage to the brain by reason of a hemorrhage or growth of a tumor, have lost the capacity to understand the spoken word. There are very few cases in adult life that are entirely pure. There is generally a good deal more lost than the understanding of the spoken word. In certain cases, it can be shown that these people who have had the ability to understand what is said to them, still have entirely normal hearing and still have a normal capacity to understand sounds other than speech. There is no loss of hearing; they are not deaf. There is no loss of the "second level" function of the hearing capacity. They still know the difference between the telephone bell and the dinner bell; they still know sounds apart and know the meaning of those sounds accurately and with entire ease and skill, but the meaning of the intricate series of sounds which constitute the spoken word is gone from their minds.

That is an exact parallel to the situation which we see in the visual sphere, in the reading cases where an adult has lost his reading skill. It is an exact parallel to the situation we see as developmental alexia or congenital word blindness in the developing child—a youngster who has normal vision but cannot learn to understand the printed word. Carrying that same concept over from this double source, that is, from the ideas derived from adult cases with an acquired word deafness, and from comparison with children who have a congenital word blindness, we anticipated that we would find a considerable number of children whose difficulty was due to congenital word deafness, i. e., to an inability to recall the previous exposures to word sounds with sufficient accuracy so that they could recognize them again when they heard them. If recognition does not come and the handle for various concepts is lacking, the word does not come and intelligence is going to lag. This

concept of word deafness is not new and yet we do not know how many cases there are. There have been cases recorded in the literature for a great many years past, but very sparsely—and it has generally been looked upon as an exceedingly rare condition. As a matter of fact, from our own studies, I believe there are a great many more cases than we have yet recognized and the reason they have been looked upon as so rare is because the majority of cases with this difficulty have been allotted to one of two other groups. They have been looked upon either as fundamentally defective and hence not developing their language function or as deaf and have drifted into deaf and dumb asylums. It may be that many of those to be found in deaf and dumb asylums are cases of congenital word deafness.

When it comes to a selection, to a diagnosis as to whether in a given child we are dealing with a total intellectual defect or with an expression of this special language delay or congenital word deafness, I must confess that we are quite at a loss. We have, as yet, no accurate diagnostic criteria by which we can say whether we are dealing with a specific language delay or with a general intellectual retardation. Our best approach to that, I believe, is in the matter of re-training. When we come to study other developmental delays in language and in the learning of motor skills, as in the developmental alexia or congenital word blindness and in the apraxia of childhood, we find that the best approach and the one which yields the best return for teaching efforts is to find the smallest possible unit which the child can handle, and begin a gradual reconstruction of the sequences or series of the smaller units; e. g., in the reading disability cases, we frequently have to go back to a simple phonetic structure, teaching the phonetics of every single letter of the alphabet and then gradually blending these in sequences.

We have a twenty-five-year-old carpenter who has never learned to read beyond second grade skill, yet even in these days of depression he has a job and has three men working under him, so that one must say that there is some intelligence and some manual skill available in that man's mind, yet his reading has never gone beyond second grade. It is marvelous to note the rate at which the man is taking hold of the learning of reading by a simple reduction to the smallest roots, not throwing the whole word at him at once, but rather a synthetic building up of words from their phonetic units. It took only one session to give him the rules for the final "e," to show him how it affects a preceding vowel sound.

When we stop to think of the latent possibilities in teaching the reading cases, it may be worth while to carry that same concept over into the field of teaching speech cases delayed in the understanding of words and consequently drifting gradually toward a defect by deprivation, and becoming obviously feeble-minded. In selective cases of this sort, I think an effort to teach language by reducing it to the simplest possible forms—to the simplest possible phonetic units—and gradually building up the capacity to remember and reproduce sequences of articulatory sounds, is without much question, the most profitable attack on the whole problem.

I do not know where we are going with all these studies, but we have seen some cases in which we feel there was a great deal to be gained by teaching language on the oral or spoken side in that general way. The limitation of the understanding of the spoken word, obviously, will have a direct and immediate effect on intelligence, since without the word, without the handle for the concept, the concept itself will not be planted and the youngster will not have the intellectual material either to work with inside or to communicate with others on the outside. The reading disability cases where there is no difficulty in spoken language are seriously handicapped academically but not intellectually. Some youngsters who would never learn to read without very special teaching have very high intelligence quotients. We have seen reading disability cases who have spent three years in school with no progress whatsoever in being able to read or write, with intelligence quotients of 135, 140 and 145. I think that a latent intelligence may co-exist with a comparable difficulty in understanding the spoken word of such a degree that it will make the child appear to be defective. I have a feeling that it will be more than worth while as we go forward to undertake constructive and selective training to see whether we cannot, by encouraging the language function, develop an intelligence which might otherwise remain latent.

The Salmon Committee on Psychiatry and Mental Hygiene invites the Medical Profession and their friends to the Fourth Series of

THOMAS WILLIAM SALMON MEMORIAL LECTURES

to be given by

SAMUEL T. ORTON, M.D.

Professor of Neurology and Neuro-Pathology, College of Physicians and Surgeons

FRIDAY EVENINGS (8:30), APRIL 10th, 17th, 24th, 1936

at

THE NEW YORK ACADEMY OF MEDICINE

2 East 103rd Street

DEVELOPMENTAL DISORDERS OF THE LANGUAGE FACULTY, AND THEIR PSYCHIATRIC IMPORT

April 10th—Language Losses in the Adult as the Key to the Developmental Disorders in Children

There exists a very close clinical parallelism between losses in the language faculty due to injury or disease in the adult and developmental disorders in children, as was first clearly pointed out by Hinschelwood in the case of reading. One of the cardinal facts recognized in the aphasias is the concentration of the language faculty in one cerebral hemisphere (unilateral cerebral dominance). The child starts out with no one-sided superiority as far as we can determine and two major factors interplay here in fixing the pattern—heredity and training. Intensive studies of handedness, eyedness, and footedness have demonstrated the existence of every degree of intergrading between right and left sidedness, and the existence of such a series suggests that comparable intergrading occurs between the two hemispheres in those areas which control language, giving rise to developmental disorders. The striking concurrence in certain families of left-handedness, motor intergrading, and the language disorders supports this assumption.

April 17th—The Syndromes of Disorder in the Development of Language

1. Developmental alexia (congenital word blindness—strephosymbolia).
2. Developmental word deafness.
3. Developmental apraxia.
4. Motor speech delay. The clinical analogy of motor aphasia.
5. Special writing disability. The analogue of motor agraphia.
6. Stuttering.

April 24th—Treatment and Psychiatric Interpretation

A brief review of the general principles of the specific treatment of each syndrome.

A discussion of the relation of these syndromes to the emotional and mental development of the individual. In some cases the time relations are such as to indicate that the emotional disturbances are distinctly secondary to the language disorder; in others the reverse is true. Any attempt at assignment of a causal relation to either however is probably valueless since they become so intimately interrelated that treatment to be successful must take into consideration both the organic factors and the emotional status.

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on the Evolution of the Human Brain

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AND SOME OF ITS DISORDERS

by the eminent neurologist

DR. SAMUEL T. ORTON
of Columbia University

TO BE GIVEN IN THE DUPLEX HALL OF THE MUSEUM
77th Street and Central Park West
New York City

FRIDAY EVENING, MAY 15, 1936
at 8:15 P. M.

This lecture is provided under the terms of the generous bequest to The American Museum of Natural History made by the late JAMES ARTHUR of New Rochelle New York, who was an Annual Member of the Museum

(OVER)

The exclusively human faculty of language (speaking and understanding speech, reading and writing, and the use of meaningful gestures as in sign language) is controlled from a part of the human brain which is enormously expanded as compared with the similar area in the highest apes. It is also peculiar in that only one side of the brain is necessary for normal language functioning. A very small area of destruction by injury or disease will give extensive disorder of speech or reading if it strikes in the language zone and in the controlling or dominant side. A similar or even larger destruction in the non-dominant side will have no effect on language.

Disturbances in acquiring this one-sided brain habit in certain children are believed to underlie an inability or delay in learning to speak or to read and write. The master half of the brain is usually, although not always, opposite to the master hand, so the problem of right and left handedness, right and left eyedness, mirror reading and mirror writing, becomes of interest in these children.

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pp. 58-68, January, 1939

A Neurological Explanation of the Reading Disability

With Some Remarks as to the Value of This Explanation in Treatment

By SAMUEL T. ORTON

I AM going to present to you this afternoon a brief theory of the reading disability in its simplest terms and call attention in a way that I have not done before to the importance of the theory, not merely because of its academic interest, but because of its very great practical importance in treatment.

It is of such practical importance to us, first, because it calls attention to the frequency of complicating disorders in other parts of the language function; second, because it serves as an active aid in treatment; and, third, because it helps in determining the methods which shall be used for fundamental correction of the disability.

There are certain facts to be presented to you briefly. These facts are as follows: We know that the normal adult uses only one side of the brain for reading. This is not theory; this is an established fact with a background of observations of more than fifty years, and today it forms a part of the working capital of every neurologist and every neurosurgeon in his diagnostic work. Therefore, it may be put down not as theory in any sense of the word but as an accepted fact. Another fact of importance to our theoretical discussion is that the part of the brain which is used for reading is not necessary for vision, but is a part which has to do with the memory of the word picture rather than the seeing of the word. This is very important and it is also demonstrable in a factual way, since it can be shown very definitely in the cases of pure alexias, as they are called (that is, in cases of adults who have known

how to read and who have lost the ability to read because of a brain injury), that there is no change in their vision, there is no alteration in the acuity of their vision, nor is there any change in their ability to use vision in interpreting objects, in understanding maps, pictures, diagrams, or any other material except the instant and immediate recognition of words.

One other problem that comes up is the factor that shall determine which side of the brain will be the controlling or dominant one in any individual person. Here we again find material which is of a factual nature. Sufficient observation has accumulated in the past so that we can say with little question that it is a combination of hereditary and environmental factors that determine which side of the brain shall be the master or controlling half in any given individual. This again, as I say, is so well supported that it belongs among the factual rather than the theoretical factors.

The theory which I have offered is that some children—roughly somewhat over 10 per cent of the total school population—encounter a difficulty of greater or less degree in establishing this normal adult pattern of one-sided predominance in brain control, and hence have a real reason for disability; in other words, have a real disability which is explainable on organic grounds. There are extensions and derivations from this theory; for example, the question of what is happening in the nondominant hemisphere from the physiological standpoint, and whether or not activity in the nondominant hemisphere may account for the presence of reversals and mirror reading. It was shown by my research program in Iowa a number of years ago that the presence of reversals is statistically significant in the reading disability cases. There are other questions concerning the relationship of the dominant to the nondominant hemisphere, but they are really questions in which criticism is only valid when it is offered by those who are familiar with brain anatomy, brain physiology, and particularly with the brain pathology of the aphasias, alexias, agraphias, and other losses in the language function. In other words, criticism of the theory, except in its

more general or widely superficial aspects, is valid only when it is offered by trained neurologists. When it comes from any other source, it rests on inadequate knowledge and may be safely disregarded.

Today, therefore, these interesting and in part as yet unsolved parts of the theory will not be discussed with this audience. The skeleton theory which I have presented to you above, however, will be discussed from the point of view of its practical value. The idea that the child has not been able to establish the normal adult habit or pattern of using exclusively one side of the brain for reading, writing, spelling, and the learning of the skilled movements has very practical advantages, as well as the marked academic interest which naturally adheres to it, and I want to call your attention to these in more or less detail this afternoon.

They are, first, the recognition of the complications in other functions which are governed from one hemisphere of the brain; second, the active aid in the treatment to which the theory may be put; and, third, the part that the theory plays in determining the methods of treatment.

To take these in order; first, complications. Pure cases of reading disability are, of course, seen. We have had a good many cases among our records in which no complicating factors are to be found in other functions. But in a considerable proportion of cases of the reading disability there is evidence of difficulty in acquiring other functions which rest on the same physiological pattern of one-sided control from the brain —for example, disorders in speech, special disability in spelling, special disability in writing, failure to acquire skilled movements with normal ease and accuracy, difficulty in learning foreign languages after English has been mastered, and, as a secondary result, a very poor vocabulary acquisition which is to be seen in both the recognitive vocabulary as used in reading and in the recall vocabulary which is used in self-expression.

I cannot emphasize too strongly to you the importance of a complete series of examinations by someone who really

understands the whole problem of unilateral cerebral dominance, that is, speech, reading, writing, spelling, and the skilled movements, and the establishment of an adequate vocabulary in all cases of severe reading disability. All too often examinations of reading are carried out as though this were an isolated function and disorders in other language functions are left unrecognized and uncorrected and still acting as real academic obstacles to the child.

The second point which I shall emphasize this afternoon is the active aid which the theory offers in treatment. There are here three points of application. First, the advantage to the patient himself in eradicating the feeling of inferiority, in combating the charges which may have been made by teachers who did not understand him, saying that he was inattentive, lazy, stupid, and so forth. This will often give him an adequate degree of self-confidence really to tackle the job of relearning a subject in which he has encountered failure. This is a very important point. It is most essential in order to get a fundamental correction, not only of the reading disability but of its by-products; in other words, of the inferiority feeling and the inadequacy which results because of the failure. It is very important that a child himself understand why he has met a difficulty and that he be given some idea of the cause or source of that difficulty, which is acceptable to him, without assuming that stupidity, laziness, inattention, lack of effort, and so on, were the cause of his past failures.

The second point in which the theory is of active help in the treatment is in explaining to parents of the children why there is need for the large amount of special work, with its implied need for extra charge by the school to carry on the remedial work properly.

The third point in which the theory is of importance is in explaining the disability to teachers so that they may gain an understanding of the child's difficulty in its true sense, and not misinterpret his puzzles and confusions as due to inaccuracy, to slovenliness, to carelessness, to thoughtlessness, to lack of attention, to distractability, and many other such fac-

tors. If the teacher really understands that there are organic disorders which may explain the fact that the child will on the same page call the word "was" correctly half the time and call it "saw" the other half of the time; and if the teacher really understands that that is explainable on an organic basis, it helps him or her to reach that feeling of sympathy and tolerance which are cardinally essential to the most effective remedial retraining.

It is interesting to note the reactions of different people to these three factors. Some of my older patients have told me about the feeling of relief that has come to them when the theory has been explained and they have come to have some understanding of why they should have difficulty while their schoolmates on either side of them have advanced rapidly in this particular subject. It is less common with the younger children to have such an expression of relief, but its effect is often to be seen in their change in personality. It sometimes seems almost miraculous—the relief which has come with their feeling that at last their disability has been understood, and that they are in the hands of sympathetic and understanding teachers who are not holding them responsible for errors because of slovenliness or carelessness or lack of effort. Several of my older patients have told me that they felt this was the most important yield of the whole program of retraining. It was the thing that made more difference to them in their ability to correct their difficulty than any of the technical procedures which we later presented to them.

Recently in discussing these three points of the advantage of the theory with a group of teachers, one remedial teacher spoke up and said that in his opinion the third point, that is, the understanding by the teachers of the organic source of the difficulty, was the most important, especially in gaining the cooperation of other teachers who came in contact with the same child. Thus, for example, the teacher in mathematics would not hold the child responsible for errors which come through reversals and misreading "12" for "21" and "16" for "61," and so forth; or he would understand why a

given child begins by adding in the wrong direction and carries his numbers to the right instead of to the left, as he should. A teacher of remedial reading who is working to correct a child's reading should have the cooperation of the teacher who is, for example, teaching history, so that he will understand that that child should not be expected to read the same allotment in the same period of time outside of school as the other children are required to do.

The infiltration through the whole school faculty of an understanding of the problem as it is presented is of extreme importance and, unless this be done, I feel that the program usually does not meet with the most efficiency. In other words, the retraining cannot be most effectively employed unless all of the teachers understand the obstacle and unless allowance is made for the child's handicap in other subjects than merely that specific one in which the remedial measures are being undertaken.

In that same discussion with a group of teachers, the headmaster of one of the schools, who was naturally interested in administrative matters, spoke to me and said that he felt the greatest help of the theory was in having something that would enable him to explain to parents why their child needed more time, more special attention, and frequently a larger tuitional charge than did other children.

So the importance of these different points varies with the viewpoint of the observer. They are all important and none of them should be overlooked. They should all be capitalized, and the matter should be explained to the child so that his own feelings of inferiority and inadequacy can be combated. The matter should be explained to the parents so that they are willing to support the program which is essential to retrain the child, and it should be explained to the teachers so that they will cooperate to make the program a unitary one rather than a scattered attack on one isolated sore thumb, so to speak.

The third major reason which I have suggested as to the value of the theory is the influence on methods of treatment. I cannot go into this in very great detail with

you, chiefly because much of it rests on an intensive neuropathological and neurophysiological basis and can only be explained by an understanding of that particular type of material, but I can mention this: That visual factors, particularly those of eye movements and those of minor visual errors, do not loom so large when we appreciate that we are dealing with a malfunction of a memory area of the brain and not with a malfunction of the visual areas. It is easy enough for any of you to demonstrate this for yourselves. The same child who misreads "was" as "saw" will copy it as "was" consistently. He does not copy backwards, hence he does not see it backwards, and there is probably no such thing as the popular conception of mirror vision. At least I have never seen it. The mirroring process is in the mnemonic, or memory, centers and not in the visual centers, and the child sees things in exactly the same orientation as we do, but he misinterprets them because he misreads them. He sees it as "was" but he interprets it as "saw."

When you think of that you will see that the attention that has been paid to a maladjustment of the eye movements, to reversals and backward shifts of the eye movements, and the attention which is being paid in some quarters to very minor visual errors is probably not as important as has been supposed. There is no change in the vision in the case of acquired alexia. An adult who has learned how to read and who has lost the capacity to read because the alexia center in the angular gyrus has been destroyed by a tumor or bullet wound or whatnot does not lose any of his visual acuity, nor does he lose the capacity to use his vision for any other function except the immediate recognition of the word. On that basis I think we can exclude very minor visual errors and many of the abnormal muscular movements which form the core of many retraining programs of today and which probably are secondary symptoms rather than causative factors.

I think it should be said that retraining programs based on these concepts are of value. They will certainly produce results, as can be demonstrated, but it is clear, I believe,

when we understand the theory that they are treating symptoms and not treating the basic disorder. It is a symptomatic treatment when we attack the movements of the eye rather than a fundamental treatment of the disorder itself, and certainly no disorder in the eye movements will account for the presence of a complicating factor in the understanding of the spoken word or in speech. In other words, the auditory function is not affected by a visual defect, and we do see complications coming to the fore in reading disability cases with such frequency as to convince us that we are dealing with part and parcel of the same physiological process, and that the theory covers the understanding of the written word and its reproduction in speech and the acquisition of skilled movements. They are all functions which normally reside in one hemisphere of the brain of the normal adult. When we think of the child's confusion as to whether the word he is looking at is "was" or "saw" because of a memory factor rather than a visual factor, when we understand why the eye movements, reversals of eye movements, occur, then we can see them as secondary symptoms to his uncertainty as to which way to read and not as the cause of his poor reading. While treatment to better the eye movements will improve reading, as it demonstrably has done, we are not really attacking the cause of the trouble, but we are merely treating one of the outstanding symptoms. This, I believe, will apply equally to many efforts to explain the reading disability on the basis of small visual defects. While here again, when the attention is focused on the details of the word there is often marked improvement. Yet it cannot be considered complete and is of no value in explaining complications such as auditory and speech disorders which are so frequently coexistent with the reading disability, and which are entirely understandable on the basis of disorder in acquiring the one-sided pattern of brain control.

The theory which I have offered to you is one which is inclusive enough to explain not merely reading disability as an isolated difficulty, but all of these commonly encountered com-

plications which, as I say, are very often frequent enough to obstruct seriously the child's progress in school even after the reading has been completely corrected. I have recently seen, for example, a youngster who had a striking reading disability in English many years ago. We undertook an intensive retraining program, which was completely effective. Today the child reads much better than the average boy of his own age in the private school in which he was placed. Last year, however, he encountered serious difficulty with Latin, and his mother questioned whether or not the Latin difficulty had any relation to his old reading disability. The school immediately replied that that was impossible, since he read so well in English. Fortunately the mother recalled that I had made the remark to her several years ago when we first saw the boy that he would encounter difficulty with Latin and French unless they were presented along special lines which would overcome the difficulty. She brought the boy back to me, and I found that he presented in his Latin very much the same trouble which he originally showed in his English. In other words, his English disability had been entirely corrected but his Latin difficulty was not understood, and he was being charged with being inattentive and disinterested in Latin when, as a matter of fact, he had actually met a recurrence of the old obstacle in acquiring the new language.

We undertook the retraining of that boy, starting on an auditory basis, and we taught him his Latin vocabulary by ear exclusively instead of by eye throughout the summer. We taught him to speak the words and to understand them by hearing. Today that boy is almost at the head of his class in Latin in a school with very high scholastic standards. In other words, the difficulty in Latin has been overcome as was his difficulty in English years ago.

Some of you may have questions which you would like to ask about the material which I have presented to you this afternoon. I will be very glad to answer these, with certain reservations. I cannot answer questions which involve problems of the neurological background exclusively. I would be

glad to do so, but it is obvious that that can be done only to an audience which is neurologically trained. Moreover, I cannot answer questions which apply to individual cases. The variations which occur from case to case in these disabilities are so great that no general rule as to treatment is applicable, and one must know the factors as presented in an individual case before one can give an opinion as to what method should be applied to a particular boy.

With these two reservations, I shall be glad to answer any questions that you may care to present.

CHAIRMAN BAIR: Dr. Orton has long since given me abundant proof not only of his genius but of his kindness, and I know that this is the appropriate time for us to break down what he has said with a great many questions.

Q. Dr. Orton, did you indicate anything as to the line of approach which you would make in correcting difficulties in reading?

A. That is a very highly individual problem, as I suggested a few moments ago. It depends on the symptoms presented by the individual child. It requires an analysis to see how much complication there may be in speech and in the motor field, as well as in reading; and the treatment varies with the findings of that analysis. It must be a broad analysis; it must be a broad examination. It covers speech, movement, reading, writing, and spelling and cannot be too limited. Sometimes the major part of the retraining is aimed at an increase of the oral vocabulary—the word understanding from the verbal standpoint—sometimes it is aimed at a better phonetic interpretation of the printed word so that the child can sound out the word for himself and understand it. It is of no value to the child to be able to sound out letters and put the word together if he doesn't know what the word means after he sounds it out, so you must first investigate the auditory understanding and find out whether it is adequate for oral reading. As I have stated above, the program of retraining is a variable one, depending on the amount of the disability and the complications which enter into it. I should say that over 50 per cent of our reading disability cases show disorders in other of the fields as well as in reading when they are adequately analyzed; considerably less than 50 per cent are pure cases.

Q. In a school system of approximately six hundred pupils, you would expect, in the light of the figures you have given, to find just about fifty pupils who are having reading difficulties. Is that right?

A. That is right.

Q. How many of these pupils would you expect one teacher to handle? Would you expect the regular grade teachers to handle these pupils or would you expect to have a specialist in the field in a building of six hundred people?

A. I think it depends very largely on the severity of the cases you have encountered and also on the level of the educational ladder that the child has reached before the disability is recognized. If the children are caught in the first or second grade, a very considerable amount of retraining can be done in groups so that one teacher can handle a number of children. That has been adequately demonstrated in one of the schools here in New York City. If, however, you encounter a youngster in the secondary schools who is practically ready for college with a reading achievement of about the fifth grade, you cannot possibly hope to put him in a class and do anything with him as a member of a group. He must be retrained individually by a tutorial procedure.

In general I should say that one can apply mass procedures when the cases are recognized in the first or second year, but that after that time individual work will probably be required for each case. I would further modify that by saying that if the case is an extreme one even in the first or second grade it may require something more than group work; it may require individual work as well. You see, the cases vary greatly in the severity of the disability. The degree of their reading disabiilty is the important factor, and where you have a very extreme case, you must apply more extreme measures of retraining.

Q. Is dominance established early enough, say by six or seven years of age, to really begin the work on the printed page?

A. We really don't know the factors that enter in there. It is highly probable that auditory dominance has been well established at that time. In the majority of children, motor dominance has been established by that time, so that the selection of the master hand has been made, but visual dominance is not always established at six years. It is in those children who have not established visual dominance that you find the selective reading disability without complication in the motor or auditory field.

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VISUAL FUNCTIONS IN STREPHOSYMBOLIA

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NEW YORK

Children who make little or no progress in learning to read during their first two or three years in school quite naturally are often referred to the ophthalmologist, and some of them undoubtedly need corrective lenses. However, many, if not the majority, of them have adequate vision and in reality present neurologic problems. One owes a considerable debt to two English ophthalmologists—Morgan, who described the first case of congenital word blindness in 1896, and Hinschelwood, who published a small monograph on this subject in 1917. In his report Hinschelwood included several cases of acquired word blindness, as well as a group of the congenital type, and emphasized the striking parallelism between them; because of this likeness, he ascribed the occurrence of the syndrome in children to a failure of development of the cerebral cortex in the neighborhood of the angular gyrus.

In 1926 I studied several cases of delay in learning to read and was struck by the inability of the children to differentiate "b" and "d" and "p" and "q" and their tendency to read many words from right to left, instead of in the usual direction, which led to uncertainty in their distinguishing such words as "was" and "saw" and "on" and "no." I found, also, that some of them showed an unexpected facility in reading mirrored print and that some also had a native skill in producing mirror writing. To account for these observations and to bring the whole syndrome into better consonance with advancing neurologic views concerning cerebral localization, I offered the theory that the condition in these cases was not the result of a pathologic factor, such as Hinschelwood's cortical agenesis, but a physiologic deviation due to failure of aquisition of the normal adult pattern of complete dominance of one hemisphere of the brain.

In cases of loss of acquired visual functions, three distinct steps, or levels, of elaboration in the brain can be recognized. The first permits only the seeing of objects of the environment but does not tell the meaning of the things seen; the second adds the meaning of objects, maps, pictures, etc., but it requires a third step—or relay—to permit the reading of words. These three steps are recognized by neurologists in the three clinical syndromes of cortical blindness, mind blindness and word blindness. It is generally believed that it is only at the third level that the principle of unilateral dominance applies, and there are reasons for believing that at this level the records, or engrams, in the two hemispheres of the brain are opposite in sign, or antitropic, to each other and that one engram must be elided to prevent confusion. This elision of the engram of the nondominant hemisphere seems to occur only at the third, or mnemonic level, since only here does a unilateral

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Read at a meeting of the New York Academy of Medicine, Section of Ophthalmology, on Feb. 15, 1943.

The Rockefeller Foundation is furnishing aid for the research program on which this work is in part based.

lesion completely destroy function, as can be seen in cases of acquired alexia. Learning to read, therefore, according to this envisagement, entails the elision of one of the two antitropic records, or engrams, and faulty or incomplete elision would result in uncertainty in mnemonic recall of orientation and progression, such as is seen in children with congenital word blindness.

It should be remembered that these reversals of form and direction are to be seen best during the first few years of learning to read, and that after continued exposure they largely disappear, although frequently in an older child the tendency to reverse can be demonstrated by using unfamiliar letter combinations, such as nonsense syllables. The confused memory patterns which interfere with recogni-

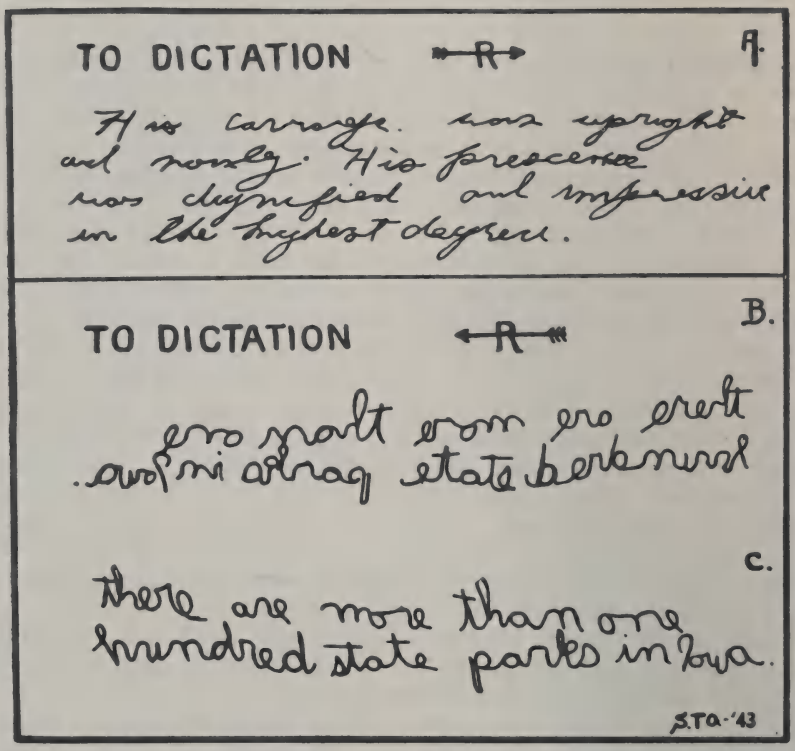

Fig. 1.—*A*, tracing of the handwriting of an 11 year old girl, written to dictation with her right hand; *B*, a tracing of her mirror writing, also made with her right hand, after only two or three trials of this procedure, and *C*, a tracing of *B* reversed by printing through the back of a negative, so that the product can be more readily compared with *A*.

tion in reading are also to be seen in the same children when they attempt to spell, and reversals in spelling persist after the child has learned to read. The most striking evidence of antitropism comes from some persons with special writing disability, in whom skill in mirror writing lies dormant and unsuspected. One of my patients who could not learn to write legibly in the common, or dextrad, direction could produce creditable mirrored script with the first attempt at sinistrad progression.

This physiologic theory offers a much more favorable prognosis than did its predecessor, and the work of my associates and myself in retraining, as well as

extended observations during the last eighteen years, has, I believe, substantiated it. As descriptive of this syndrome in cases of reading and spelling disability I offered the term "strephosymbolia," or "twisted symbols," as being less misleading, especially to the layman, than the older term "congenital word blindness." To the neurologist the term "word blindness" means a loss or lack of the ability to recognize words although vision may be intact, but to the layman the term infers an inability to see. Moreover, I believe this disorder is hereditary rather than congenital, and I much prefer to call it developmental than either congenital or hereditary.

One of the visual functions which is often discussed in connection with reading is that of eyedness. There is a common misconception that the eye selected for sighting—the master eye—is the eye with the better vision. This is not always true. As an example, 1 of my patients wore a + 2.00 D. sphere and a + 1.00 D. cylinder for his right eye, while for his left eye a + 1.25 D. sphere and a + 0.50 D. cylinder was prescribed. In spite of the greater errors in his right eye, he used this eye consistently for sighting. The master eye is usually on the same side as the master hand, but cross preferences in either direction are to be found. Sighting is a function of the extrinsic ocular muscles, which act to bring the object observed, the pupil and the fovea centralis into line. These muscles are of the striated, or voluntary, type and are under the control of the motor centers of the brain adjacent to those which control handedness. It is possible that the right or left homonymous parts of the peripheral portion of the retina might have a superior equipment and so determine the eye most apt to be attracted to a distant object and thus fix the eyedness in early infancy before binocular fusion has begun. However, the frequency with which left eyedness and ambiocularity occurs in families in which there is also a preference for the left hand in some members leads me to the belief that eyedness is dependent on hereditary factors which govern the choice. It must be noted, however, that the many crossed patterns of eyedness and handedness would imply separate hereditary factors for the areas of the brain which control the eyes and those which control the arm.

The handedness pattern is open to much greater environmental influence than is eyedness, although there is evidence that the native eyedness pattern can be shifted also. Shooting a rifle was the factor in 1 such case, and my colleagues and I have observed children in whom a spontaneous shift from the left to the right eye has been noted in repeated examinations over a period of years. Some left-eyed persons can aim a rifle with the right eye only if the left eye is closed, or covered, while right-eyed persons usually learn to disregard the image in the left, or non-dominant, eye and can aim a rifle with both eyes open. In the case of a shotgun the situation is different, since without sights on the gun it may be aimed with the left eye. A priori, one might think that in aiming at a distance this would be a negligible factor, but that it does influence the accuracy of aim is recognized by gunsmiths, who build special stocks with a slight offset for those who shoot from the right shoulder but aim with the left eye. Accuracy in the use of a shotgun is said to be much improved by this procedure, and the same principle may apply in certain types of machine guns.

Some of the simpler tests of eyedness are not entirely trustworthy when used alone, and as a consequence my associates and I make use of a battery of tests to determine eyedness. In this connection it is interesting to note that the manoptoscope devised by Parsons, in our experience, frequently gives results out of harmony with those of other tests. Parsons used this instrument in his examinations on which he based his conclusion that left eyedness is evidence that a given child was originally intended to be left handed and, further, that eyedness determines which side of

the brain shall be the dominant one. He held that when left eyedness is found in a right-handed person it is evidence that training has influenced the handedness pattern and that the right-handed pattern is implanted in many naturally left-sided children because the right hand is used habitually by so large a proportion of both mothers and teachers. However, we have seen a number of left-handed children who are right eyed, whereas training right-handed children to use the left hand, either purposively or accidentally, is rare. Many persons, moreover, are neither definitively right eyed nor left eyed, and may be termed "ambiocular."

In 102 patients with reading disabilities whose records I have recently reviewed, the following distribution of eyedness patterns was found: right eyedness, 40 patients; left eyedness, 37 patients, and ambiocularity, 25 patients.

The left-eyed and the ambiocular persons together numbered 62, as against 40 who were right eyed—obviously a much higher proportion than one would expect in the population at large. Of the 40 patients who were right eyed, 12 were either left handed or had mixed right-handed and left-handed habits. Of the 37 who were left eyed, only 5 were left handed, but 17 showed a mixture of handedness patterns or gave a history of having been shifted to right handedness in childhood. Of the whole group of 102, 69 showed a crossed or mixed pattern of handedness and eyedness, and 83 gave a family history of left handedness or of language disorders.

My interpretation of these results is that left eyedness is not the cause of the reading disability but rather indicates that there is present in these persons a tendency toward use of the right hemisphere of the brain, i. e., left sidedness. This tendency may or may not involve those parts of the brain which are of primary importance in reading. The symptoms seen in the left-eyed and in the ambiocular patients do not differ from those seen in the right-eyed persons, and while covering the eye might lead to a change in eyedness, one would not expect any influence on the higher centers of the brain which are involved in strephosymbolia. Each macula is connected with both calcarine areas, and Sherrington's flicker experiments demonstrated that functionally the two eyes are interchangeable; it would seem therefore to make no difference which eye is used for sighting, since the image from either eye is probably relayed to the higher centers on both sides.

A second group of visual functions which is to be considered in connection with the reading disability includes the various refractive errors. There is no question that serious refractive disorders will interfere with reading, but many persons with minor degrees of myopia, hyperopia and astigmatism learn to read easily. Moreover, many persons with reading disability have normal refraction. When more serious errors are present, not only does their correction with appropriate lenses fail to enable the child with strephosymbolia to read without special instruction but even while he is wearing such lenses such a child exhibits the same errors of orientation and progression as do other children with strephosymbolia. This is, I believe, what one would expect on theoretic grounds. I have already mentioned the tendency to reversals in the mnemonic recall of previous exposures to the word, which must be used in order that it be recognized when it is presented again. This point is often difficult for the layman to grasp, since recognition of a word at sight seems to be simultaneous with seeing it. This, of course, is because the transmission of nerve impulses from the arrival platform to the region of the angular gyrus is too rapid to be registered in consciousness. The existence of a special zone of the cortex of primary importance in the function of word recognition is, however, clearly demonstrated in cases of acquired alexia, in which selective loss of the ability to read occurs without loss of the ability to see or of the capacity to

recognize objects, diagrams, maps, etc. These last functions are sometimes disturbed in cases of large occipital lesions which have involved the rest of the occipital cortex of both hemispheres, and acquired alexia is rarely, if ever, pure. A homonymous hemianopsia is frequent, but acquired hemianopsia can occur without alexia, and alexia is combined with it only when it involves the master hemisphere and when the lesion extends far enough forward to cut both the homolateral path from the calcarine cortex to the region of the angular gyrus and the heterolateral path from the opposite calcarine cortex by way of the corpus callosum (subcortical word blindness of Dejerine). This, again, demonstrates the adequacy of one hemisphere, since a lesion which cuts only the homolateral pathway does not cause alexia even though it is in the master hemisphere. While hemianopsia is the most common complicating picture, other symptoms, such as agraphia and varying degrees of aphasia, are also often found; indeed, in the acquired case pure alexia is so rare that some neurologists have questioned its occurrence. Persons with strephosymbolia, on the other hand, often show the alexia syndrome in exquisite purity. Handwriting may or may not be affected, and when it is not,

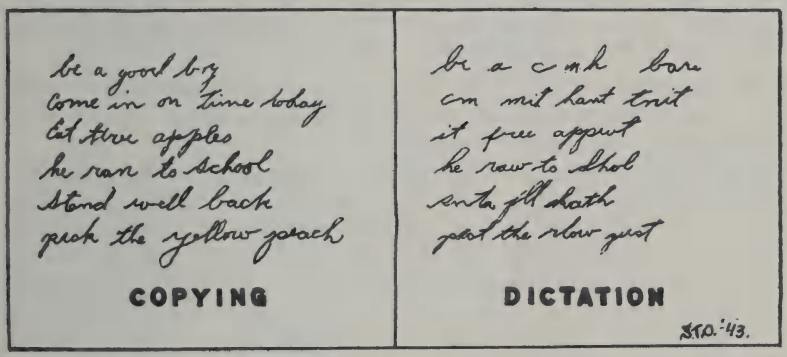

Fig. 2.—Carbon paper tracing of the writing of a 21 year old patient with strephosymbolia, showing the contrast between copying and writing to dictation (see "Addendum").

an illuminative demonstration of the mnemonic character of the disturbance and the adequacy of vision can be made by comparing the child's ability to copy accurately with the errors he makes in attempts to read or to write to dictation. In both these processes he calls on his visual memory, and in both he makes the typical errors of reversal. It is difficult to see how reading "was" for "saw," "ratshin" for "tarnish" or "astrep" for "repast," or how writing "ti" for "it" or "stpo" for "stop" could result from any refractive error.

The foregoing comments may, I think, be applied equally well to the heterophorias.

In a case in my experience, the diagnosis of hyperphoria was made at about the same time that I first saw the boy, when he was 11 years of age, but his family did not follow the ophthalmologist's advice and neither glasses nor treatment was provided. The boy had been in school most of the five preceding years, and while he did not have a very good basic equipment, he nevertheless had a mental age of 9 years when he was first seen and should have been able to read at the third or fourth grade level. He manifested, however, definite strephosymbolia, and his reading and spelling abilities were below the first grade norms. An intensive course of phonic retraining was instituted; after two and a half years of this treatment he had gained about a fifth grade skill in silent reading, and his oral reading and spelling were at about the fourth grade level. At this time he was seen by Dr. Conrad Berens, who found exophoria of 8 prism diopters and right hyperphoria of 1 prism diopter at 25 cm. The gain

in reading previously recorded had, however, taken place before treatment for his heterophoria was begun.

In another case, that of a boy seen recently in Philadelphia, a diagnosis of exophoria was made, and sight reading methods were recommended, with definite prohibition of the phonic training which has been found so serviceable in retraining persons with strephosymbolia. This boy's father and paternal grandfather were left handed, and his mother had been a poor student, although we were unable to determine whether or not this had been due to a reading disability. The boy himself definitely favored his right hand in almost all activities but was left footed and left eyed. He was 12 years old and had been in school the usual period of years. Psychometric examinations by a battery of tests gave mental age ratings varying all the way from 9 years 7 months to 13 years 2 months. Even at the lowest of these ratings, he should have been able to read at third or fourth grade levels, but his reading achievement was that of a very low first grade level. He copied a second grade paragraph without errors, but he misread "left" as "felt," "was" as "saw," "on" as "no," "nip" as "pen" and "ton" as "not." In attempting to spell to dictation a column of simple words, he wrote "ol" for "low," "sa" for "ask," "egt" for "get," "bolg" for "belong" and "awy" for "way." When he was asked to read a simple paragraph printed in mirrored type, he accomplished this almost as rapidly as he read the ordinary print, whereas a boy of his age who had gained normal reading skills would require at least ten times as long for the mirrored passage. At the time of these examinations he was wearing the glasses prescribed for him by the ophthalmologist, who advised the sight reading teaching and interdicted the phonic training. I believe that with continuance of that proceeding the boy's directional confusion will persist and that he can be taught to maintain consistent dextrad progression only by phonic training and dextrad analysis and synthesis of words from their phonic equivalents.

I am not personally familiar with the aniseikonic disturbances, but I understand from others that patients with such disorders are by no means all nonreaders, nor do the nonreaders all show that disorder.[1]

Much attention has been paid to vacillating movements of the eyes, and while bad habits in this regard might easily interfere with easy and fluent reading, it is also obvious that such a boy as the one last mentioned would scan a word from either direction in his confusion as to which way it should be read and would therefore exhibit back and forth movements of the eyes as the result of his uncertainty as to direction. Moreover, such vacillating movements would scarcely account for the confusion such children show between single letters, such as "b" and "d" and "p" and "q," or for the facility in reading mirrored print, in which constant sinistrad progress rather than alternating ocular movements is required.

Finally, the data we have assembled from the study of left handedness and of various language difficulties in the family stock of children who have a specific disability in learning to read and show the strephosymbolia syndrome give what to me is convincing evidence that such children represent intergrades between right-sided and left-sided familial tendencies and that the reading disability follows fairly definite hereditary trends. In this connection it is interesting to note that the reading disability and other language disorders are much more frequent in boys than in girls. In the current sample of 102 patients, 84 were boys and 18 girls. About the same distribution occurs for stuttering. In families with this disturbance there are also more than the expected number of left-handed members and persons with delayed speech; stuttering; reading, writing and spelling disabilities, and abnormal clumsiness (developmental apraxia). In the childhood histories of children who come to attention as presenting reading and spelling problems we not infrequently find indications of developmental deviations in their acquisition of speech and motor patterns which bear out the belief expressed herein that the strephosymbolia syndrome can best be explained on the basis of confused cerebral dominance rather than of abnormal vision.

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1. Imus, H. A.; Rothney, J. W. M., and Bear, R. M.: An Evaluation of Visual Factors in Reading, Hanover, N. H., Dartmouth College Publications, 1938.

ADDENDUM.—After this paper was presented at the meeting of the academy, but before it was completed for publication, I studied the case of a man aged 21 with the strephosymbolia syndrome who, in spite of having "served time" through eight grades of the public schools in New York state, had acquired less than first grade reading skill. Figure 2 shows (1) his ability to copy from print into script, demonstrating that there was no agraphia, and (2) his floundering efforts to write from dictation. This contrast demonstrates clearly that the confusion lies in the mnemonic recall and not in visual distortions. This patient is now being given remedial instruction, and his eyes are being studied by Dr. Conrad Berens. A complete report of this case, together with the results of the remedial work and of Dr. Beren's study, will be published later.

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DR. SAMUEL T. ORTON

Some Disorders in the Language Development of Children

The production of the spoken language which, of course is about the first evidence of language development in children, is so simple that it seems almost automatic. Speech seems to come to the child without instruction but if you will think a moment, you will appreciate that everything which a child learns in the way of language is taught to him. We do see idioglossia, as Dr. Robbins pointed out, particularly in cases of twins who often develop a language of their own, having no meaning to others but fully understood between themselves. On the whole, however, the language that the child first speaks is that which he has learned from his mother or his nurse. He is being instructed constantly through what he hears. The development of his speech is a learning process and one that is approachable from the standpoint of teaching. There has been too little emphasis placed on the teaching of the spoken word in the pre-schools and kindergartens. Much stress has been placed on various activities but little on purposive language development. The fact that speech appears so early in the average child chronologically, is probably related to the race development. We have quite good evidence from fossil man that man has had brain capacities adequate for speech, and therefore possibly some kind of verbal communication with others, for approximately five hundred thousand years. On the other hand, our reading dates back scarcely five thousand years. Even in that time it was available to only a few priests and others of the educated group. Reading as a general function for human beings is very recent indeed and, even today, is for from universal even in the most civilized parts of the world.

Deviations in the development of the spoken word are to be expected. We find no consistent development which we can call "normal" for all children and deviations may express themselves in a number of ways. We may see delay, in various degrees, in the onset of speech but in some such cases, when it does come it is quite normal. We may see defects of articulation, defects of grammatical construction, defects in vocabulary and so on—all of these are evidence of some difficulty in the acquisition of language or, in other words, they are developmental difficulties. I think in the past they were wrongly called "congenital" or "hereditary" defects, although strong hereditary factors can be seen operating in certain families.

The language function at large, however, includes not only the understanding and the reproduction of the spoken word, which may be called sensory and motor speech, but also reading and writing which are respectively the sensory and motor components of graphic language—printed or written language, if you wish—and finally, there is a third form of communication of ideas, i.e., sign language. You might hesitate about accepting the sign language but when you think of what talking is to the deaf and dumb, you see it is a very serviceable method of communication. It is one

way of telling another person what one feels and is thinking about, and that, of course, is the fundamental basis of all language. It is a choice of the substitute—be it the printed word or the spoken word or gestures—for an object or a feeling in order to communicate what is going on in one individual's mind to that of another, so I like to include sign language for the sake of scientific completeness.

In practice, however, we find that the two important functions of language are the spoken and the graphic. Personally, I have spent much time on the visual language and feel that I know it better. For many years, I served an apprenticeship in the autopsy room, studying brain lesions and associating them with speech disturbances which had previously been observed in the patients on the hospital wards. Then, some twenty years ago when I was starting mental hygiene clinics for children in one of the middle-western states, I became very much interested in some youngsters who were having trouble in learning to read—trouble out of all proportion to their general intelligence and to their age and to their school training—and I have been particularly interested in this problem ever since. From my studies of these children, I feel that we can exclude the field of organic defects of the brain such as those so well discussed by Dr. Robbins and Dr. Phelps. We can assume that many of these reading cases develop on the basis of a strictly functional disorder. I cannot go into the details of that here but there are good neurological reasons for making such a statement. The functional explanation I have offered is that of a faulty establishment of dominance in the reading centers of the brain. Let me stress that: *reading* centers of the brain. I emphasize that here because many of these children are quite bright, with good "I.Q's" before they enter school. They learn quickly, have a good vocabulary, good auditory understanding and good speech.

Such a youngster, for example, after three years in a well-known private school was reading nothing although he obtained an I.Q. of 142 on standard tests. Now there is something odd if a boy with an I.Q. of 142 cannot learn the very simple process of reading. This boy had mastered his arithmetic. He knew the arithmetical combinations and had learned the numerals, but he could not be sure of his words. Among his troubles were the constant reversals and twists in the order of letters to which I have called attention in many of these cases and from which is derived the term "strephosymbolia" as a descriptive word. This youngster was given some remedial work after school by an especially trained tutor. The school, in this instance, was rather resentful of anything being done outside of their class-rooms but the parents insisted upon having the retraining undertaken. It was carried on at home and the school knew nothing as to what was being done for the boy. However, at the end of the school year they wrote a very self-congratulatory letter to the parents as to the improvement in the boy and the success of the school's training. That youngster has gone on with little academic trouble. He is a college graduate now and has held a commission in the armed

services. We have seen a similarly successful outcome in many of our reading cases during the past twenty years.

The process of reading in the adult is controlled or initiated or overseen, if you prefer, largely, if not entirely, from one hemisphere in the brain. In other words, only one hemisphere functions in the process of reading or writing. We do not know why this should be but it is true and can be observed where fractions of the language function are damaged by a stroke or other injury to the brain. In these cases any injury to the dominant half of the brain will result in extensive damage to the language function while injury in exactly the same locus in the brain but in the opposite side or non-dominant hemisphere will give no specific language symptoms whatsoever. In right-handed people, the left hemisphere of the brain is almost always the dominant one and vice versa. Whether or not our theory is right, I do not know, but I do know that the methods of retraining which we have derived from that viewpoint have worked. I do not claim them to be a panacea for reading troubles of all sorts but I do feel that we understand the blockade which occurs so frequently in children with good minds and which results in the characteristic reading disability of the strephosymbolic type of childhood.

Studies of the language function in the adult show, however, that it is not only reading which may be damaged by a unilateral brain lesion. Loss of the spoken word—motor and sensory aphasia—is much more common and that gives us evidence that the same principle is at work in speech as we have found in reading. Therefore we forecast quite early in our studies that speech disorders in children would be found comparable to these two types of language losses in adults. Subsequent studies have shown this probably to be true. There appears to be a marked difference in children with delayed or defective speech according to whether their understanding of the spoken word of others is or is not impaired. In some speech cases the understanding of the speech of others seems to develop nearly or entirely as well as in the average child. These are the children whom we have classified as "motor speech delay" cases. They are the youngsters who come nearest to warranting the advice so often given to parents to "Let him alone—he'll outgrow it". I cannot completely subscribe to this advice for although spontaneous improvement often occurs, it is much more rapid and more complete, in our experience, under expert guidance by a trained teacher. In general, however, the outlook for recovery in this type of case is quite good.

There is another group of children with speech difficulties for whom the prognosis is less favorable with our present limited knowledge of training procedures. These are similar to the sensory aphasia cases among adults in that they fail to understand much of what is said to them. They are sometimes called "word-deaf" children. These children are not deaf in the ordinary sense of the word. It is often possible to demonstrate that they can hear everything in their environment and that they respond naturally and normally to sounds other than speech. In other words, they recognize the

telephone bell and the door bell and can differentiate between them. Although their reactions show that they are receiving these sounds and interpreting them correctly, they do not understand words that are spoken to them. This is a difficult concept to grasp until you know something about the intricacy of the understanding of language within the brain. There must be at least three processes at work; first, the hearing itself; second, the understanding of the sound, and third, the understanding of the meaning of the word. The situation in the auditory field is much like that which we find in the visual functions of the children with the reading disability or, as it is sometimes called, "developmental word-blindness". These children show no consistent visual disorder other than the lack of a quick recognition of the printed word. They see well and often make good use of visual memories of objects and even of pictures and maps. It is only in the more complex function of word recognition from print that any obstacle is encountered. There is likewise no evidence of any peculiarity in the way in which they see things—they do not see backwards or in mirrored fashion. They often show superior visual-motor coordinations in games and in various manual skills. We have many times asked for complete eye examinations by the best trained ophthalmologists. Their reports have indicated that there was nothing wrong whatsoever with the vision of the patient.

Two such cases come to my mind. They presented such a severe degree of reading disability that we had them studied carefully from every angle to be sure that we had left no stone unturned. One was a young man of twenty-two with an I.Q. of 100 who had spent ten years in the public schools in New York State and was still completely illiterate. We have also recently seen a twenty-one-year-old veteran who had been graduated from the eighth grade in a parochial school in Cincinnati, Ohio, through his ability to learn by ear but who was unable to read or write a single word except his own name. He also had an average I.Q. In both cases we had the eyes carefully examined and the reports were entirely negative. I think there is a demonstrable type of reading disability which has no relation to vision but which is essentially a matter of the recall of previous visual impressions.

This is a point which may bear some elaboration for in the adult who is alexic, i.e., who has lost his reading as the result of a stroke or other brain injury, there is often no loss of vision. He is frequently as good as ever in interpreting pictures and visual materials of various kinds but he cannot get any meaning from looking at a printed word. It is astounding to see a man look at C-A-T and shake his head and say, "I don't know what it means". Sometimes he will read off the letters one by one and then say, "That means CAT," but as a group of letters it had no meaning at all to him; yet that same person could see perfectly and had no visual trouble. He was able to make use of what we call neurologically the First and the Second Levels of Vision. He was able to see and to make use of maps and pictures and diagrams but he could not read a simple printed word. In

other words, only the Third or Word Level of Vision showed an interruption of function. Similarly in the developmental word-blind and word-deaf cases of language disturbances in children, I believe that there is a functional difficulty, acting selectively at the Third or Word Level, in the visual or auditory areas of their brains.

I am afraid that my topic has made it necessary for me to introduce a number of things that are difficult to understand. However, I believe that in these twenty years we have gained a good insight into the background of the specific reading disability and know a good deal about the training of the strephosymbolic cases. The work in developmental word-deafness (sometimes called, wrongly I think, congenital sensory aphasia) is not so advanced but it has given us promise and considerable hope for the future. I am hopeful that in many of these cases which, if uncorrected, would go on to become feebleminded by defect, we will be able to bring about marked improvement if we are clever enough to devise the proper methods of teaching them.

Another of our early forecasts was that certain children would have great difficulty in acquiring motor skills although they were not spastics or suffering from motor disabilities in the ordinary understanding of the term. This anticipation was based on the study of adults in whom a one-sided brain lesion will not infrequently wipe out an earlier acquired skill of some kind, producing the condition known as apraxia. As an example, a person accustomed to write on the typewriter so extensively that the matter of finding the keys was entirely automatic, had, following a very minor brain lesion with only a suggestion of paralysis, a complete loss of her ability to typewrite. She could no longer remember the position of the letters on the keyboard and had to go back to the simple "hunt and peck" system of beginners.

Our studies of similar developmental apraxic conditions in children have been very fragmentary. It is a field that is still uncultivated and still open to research, but such as they have been, they seem to have led us to the recognition of a sensory and a motor type of apraxia. With the sensory type, the child does not apparently understand the motions he wants to make and with the motor type he knows what he wants to do but cannot carry out his idea. Perhaps the best description of this condition in children is "clumsiness". I wonder whether the awkwardness referred to by some observers as "double left-handedness" might not be better explained on this basis. In any case, we have found that by special training methods much can be done to help such children. They are constantly under a tremendous handicap because they cannot compete successfully in any sort of athletics, but often they can be taught to do one thing pretty well. In the case of one boy of this type, the athletic master of his school came to me for instructions. I suggested that he pick out one activity which none of the other boys could do well and try to train the boy so that he could excel in that. He chose quoits and after teaching the boy how to pitch horseshoes successfully he

turned him loose among his schoolmates. His success in this one skill was a great lift to his morale. In such cases, training which we have found most promising is based upon the analysis of the more complex activity into the simplest component units. For example, in baseball, you cannot teach a boy how to pitch until you teach him how to stand properly, how to balance his weight, how to get his arm back for a long swing, etc. By separating the patterns which you wish to teach him into units, working on each one separately and finally putting them together in a given sequence, I feel that much may be accomplished for these youngsters. Although it is too soon to make positive statements on the basis of completed studies, the viewpoint that many of these difficulties may be due to a failure in the establishment of dominance gives us at least reason to hope that we can work out successful methods of treatment.

The only general process which seems to relate to all three of these developmental difficulties of childhood—the reading and the speech disabilities and the apraxias—is that of sequence building. In reading, the individual must recall the exact sequence and order in which the letters of the word occur in space. In the spoken language, he must recall the exact sequence and order in time in which the sounds occur in a word so that he can understand it and reconstruct it. In the speech errors of many of these children there is a confusion in the order of the sounds which belong in the word. For example, one small boy told me that he lived on "Driverside River" in New York. Similarly, the apraxic cases often have no trouble in learning the simpler units of a motor skill but they have great difficulty in putting them together in sequences. It seems to me quite probable that this problem of remembering and reproducing sequences in their proper order in space and in time is associated with the problem of cerebral dominance.

SOME STUDIES IN THE READING DISABILITY

An unpublished address by Samuel T. Orton, M.D., presented at the Medical Convocation of the University of Pennsylvania, June 18th, 1945, upon receiving the Honorary Degree of Doctor of Science.

In any review of the evolution of the nervous system it is evident that there are several places in which there has been a distinct leap forward by the introduction of a decidedly new pattern of organization of nerve tissues without however discarding the older patterns. The most recent such evolutionary saltation is that which is accomplished in the vertebrates by the establishment of the dorsal chord of nervous tissues which form the central nervous system. From this point onward there is no such total revision of the building plan but rather a progressive growth and increase in importance of the head end of the dorsal chord structures. It is interesting to note that there is no major change in architecture to differentiate man's most important organ, his brain, from that of his nearest animal competitors — the great apes. The differences to be found here are, first, an enormous overall increase in size of the brain and, second, a relative increase in size of certain areas which are represented in the chimpanzee's brain, for example, by only a relatively small space but which in man's brain are so expanded as to cover the larger part of the lateral surface of that organ.

The great overall enlargement of the brain would of course increase tremendously its functional capacities merely by the provision of so many more brain cells and so many more interconnecting fibre systems but the differential growth of the lateral areas also suggests the possibility that new functions might arise there. These areas are described by the anatomists as the great association zones and there is added interest to be gained when we observe that damage or destruction in specific parts of these zones has been related to losses in functions which are exclusively human — communication by speech and by graphic means and great manual dexterity.

The animals have developed means of communicating their emotional status to others of their kind and to their enemies by means of vocal processes and bodily postures — thus the snarl and bared teeth of an angry dog or the bay of a trailing hound are distinctly indicative of their reactions of the moment — but it is man alone who has learned to use a fixed sequence of sounds as a symbol or substitute for an object or an action, to use graven or written symbols to replace the spoken words as in the phonetic languages or to indicate an idea

as in the Chinese written language, and finally, to develop manual dexterity to the high degree that is represented in the finger movements of the trained typist or the pianist, for example. These three major functions — spoken language, graphic language, and superior skills — are naturally grouped together as the three outstanding abilities which are distinctively human and they are further associated by the fact that the newly expanded cortices of the association zones of the brain play an important part in their integrity. One other fact and a curious one links them and that is that they are all under the exclusive control of one hemisphere of the brain. Thus in these functions not only must injury or disease of the brain affect a given area but it must lie in the dominant or master half of the brain while an exactly similar injury or disease in the opposite hemisphere will give no symptoms of language disorders or of apraxia, the loss of skilled movements.

This peculiarity of the brain's action is spoken of as unilateral cerebral dominance. No comparable superiority of one half of the brain is found in the animals nor does it affect the older parts of man's brain. Both hemispheres are operative together in seeing and in hearing and each operates independently in touch, and there is no evidence of any greater importance of either side. As yet no adequate explanation of this new principle of operation has been forthcoming although there is room for interesting conjecture. The controlling or master hemisphere of the brain is usually, although not always, on the side opposite to the master hand — thus, in a right handed person the left brain hemisphere is commonly the important one.

One small area of one of the association zones is known to be very important in reading and a relatively small amount of damage, providing it affects the master half of the brain, will result in complete loss of the ability to recognize a word at sight in a patient, although before the injury, he had been a competent reader. There is no interference with vision as the patient still sees the word but has no idea of its meaning; visual interpretation of objects of the environment and even of pictures, maps, diagrams, etc., may also be intact and not infrequently the individual letters can be named correctly although when in sequence in a word there is no recognition of it as a whole. Occasionally the spelling out of the letters in a word will identify it. It is an illuminating experience to see an educated man completely baffled by the word *cat* until he spells out the three letters c-a-t and then exclaims, "Oh, that spells *cat*!" This is the condition known as alexia and for emphasis let us repeat that had the patient's injury involved the half of his brain other than it did he would have experienced no trouble with his reading. Cases of alexia can not write spontaneously although many of them can copy from print into their own characteristic script, indicating that there has been no interference with the mechanics of writing but only with the recall of the letters of a word in their correct order.

This skeleton outline of the loss of reading skill because of brain damage in the adult is given here because of the rather striking similarity such cases show to the picture presented by some children in learning to read. There is a considerable variability in the ease with which school children acquire reading and there is quite a number who find this accomplishment difficult or well nigh impossible in spite of a good general intellectual equipment. Extreme cases of this disability are rare but in lesser degree it forms an obstacle to the easy acquisition of this most important subject which is sufficiently frequent to form a challenge to educators. Our own studies indicate that about ten per cent of the total school population suffer from it enough to retard their reading advancement one full school grade below that to be expected from their age and intelligence. All degrees of severity between a comparatively benign difficulty and an apparently insurmountable handicap have been observed. As an extremely severe case may be cited that of a man of average intelligence and good vision, twenty-one years of age, who had attended public schools in New York State until he was sixteen but nevertheless came out an illiterate, unable to read even first grade material and unable to write anything that would carry meaning to another.

Such marked trouble with learning to read has naturally attracted considerable attention and a number of theories as to its causation have been advanced. Perhaps the most widely accepted medically was that of Hinshelwood, an English ophthalmologist, who called attention to the striking similarity of symptoms between these children who were failing to acquire reading and those adults who had suffered a loss of reading through brain injury affecting the critical locus for this function. On this basis, supported by the fact that occasionally more than one member of a family suffered from the same trouble, Hinshelwood offered the hypothesis that these children suffered from a congenital lack of development in the brain area critical for reading.

Twenty years ago the writer, in the course of an experiment in extending neuropsychiatric service into the community, encountered several children with severe reading disabilities in the school of a county seat town in central Iowa and felt that there were sound neurological reasons for challenging Hinshelwood's hypothesis although his observations were confirmed. Like the alexia cases, these children had adequate vision and made good use of visual material of simpler organization, such as pictures and maps, and could often name the letters of a word correctly, yet were very deficient in recognizing words at sight in spite of frequent previous exposures. Moreover, copying correctly from print into script was possible even in those whose attempts at spontaneous writing were unintelligible. While certain other considerations seemed to exclude the brain defect hypothesis in these children, the close agreement between the symptoms they exhibited and those of alexia in the adult called for a theory which would include some interference with a physiological pattern common to them both and this brought the unusual plan of unilateral cerebral dominance,

or one-sided brain control, up for consideration and the thesis was tentatively considered that some factor was causing an interference with establishment of the exclusive one-sided control in reading which had long been demonstrated as the normal adult pattern. This viewpoint — that the trouble might be the result of a functional deviation rather than an anatomical defect — altered the whole outlook and gave immediately added impetus to further careful clinical observations and to experiments in educational retraining with the hope of overcoming the handicap.

When seen during the first few years of their exposure to reading, children with the special disability in this subject show a marked difficulty in differentiating the lower case letter *b* from *d* and *p* from *q* and are often puzzled as to whether w-a-s spells "was" or "saw". Such children also frequently reverse groups of letters or whole syllables not only in their attempts at reading but in their written spelling as well. Some of them find mirror writing comparatively easy and some can read mirrored print almost as well and occasionally even better than they can the ordinary form. In spelling, the same reversals and confusions in sequence of letters are to be seen and when the disability is marked there is evidence of a very faulty linkage between the letters and their appropriate sounds so that the written letters bear little or no relation to the constituent sounds of the word. Bizarre misspellings leading at times to completely unintelligible writing occasionally result. Conversely, the deficient or erroneous linkages between sound and the corresponding printed symbol can frequently be shown to be a factor in producing reading errors. Later observations in cases of isolated writing disability offered further instructive material. Two such adults — both physicians as it happened — who had labored conscientiously and long but unsuccessfully to acquire a facile and legible handwriting in the ordinary or left-to-right direction, were found when first tested and without any practice to be able to write in mirrored characters, proceeding from right to left, and to produce easily thereby a well formed script.

Together these varied observations led to a reconsideration of the possible functions of the inert or non-dominant hemisphere. Its capacity for retraining has frequently been the subject of discussion and conjecture in connection with recovery from the symptoms of aphasics who have lost the function of speech through injury or disease in one hemisphere but apparently very little attention has been paid to what it may be doing in the normally functioning brain. Obviously since the large areas corresponding to the language zones of the dominant hemispheres do not give comparable symptoms when damaged or destroyed they must be functionally inactive and it is safe to assume therefore that such activity as may be present there is suppressed or deleted since it plays no part in the functions of the corresponding areas of the controlling half. However, such suppression of this activity must be purely a functional phenomenon since structurally the two sides are equivalent and alike except that they are the right and left counterparts of each other. As yet no distinct anatomical su-

periority of the dominant over the non-dominant hemisphere has been demonstrated by autopsy studies and while there may be such differences in the finer structure and almost innumerable interconnections present in the cortex, yet we must acknowledge that the non-dominant hemisphere is adequately equipped as far as structure goes to function as a control mechanism were it not for the established habit of action whereby the master hemisphere takes full command. However, its inactivity as a controlling mechanism does not exclude a considerable measure of activity of its own below the control threshold. Thus its connections with the sensory receiving stations are intact and abundant and it seems evident that sensory data such as those furnished to the dominant side are constantly irradiating the non-dominant side as well and I believe that we may assume that they are being recorded there although this it not readily demonstrable since such records are not used for responses. There will be one major difference however, and that is that they will all be of opposite sign, that is, right-left counterparts of each other. This will be obvious from the structural relations of the two hemispheres as well as from their connections with the muscles and sensory systems of the body.

From these and other considerations the theory was offered that the special reading disability which serves as a serious handicap to academic advancement in many children may be explained as a failure in complete elision of memory records of the non-dominant hemisphere and as a persistence therefore of two more or less equipotential records, thus explaining both the nature of the early symptoms and the failure of prompt recognition of words at sight; in other words, a physiological failure to establish the normal pattern of unilateral cerebral dominance in control of graphic language, reading, spelling, and writing. To delimit this group of children with failures and delays in learning to read from those where other factors were operative, the term "strephosymbolia" was suggested. Derived from the Greek, this means "twisted symbols" and was offered as a descriptive term because of the reversals and confusions in direction which characterize the early errors in attempting to read and spell exhibited by this reading disability group.

These studies have been intensively followed throughout the entire twenty year period since the initial observations and the results of this extended program have abundantly demonstrated our earlier belief that these children with strephosymbolia are not lacking in intelligence, — some indeed have unusually good minds — are retrainable in reading even after several years' failure in this subject and that methods already available are serviceable when properly applied and conscientiously carried out to correct the disability.

Handedness, the commonly accepted measure of the native laterality of an individual, does not apparently determine the dominant side of the brain but handedness itself is probably determined by the brainedness in the majority of individuals. In other words, the superiority of one side of the brain probably

leads to greater skill with the opposite hand and foot and to choice of the opposite eye as the master or sighting eye, as well as determining the locus of the control centers for the language functions but in all of these statements exceptions must be expected. Handedness is possibly the least trustworthy of these guides since it is so open to accidental or purposive training in infancy. By and large however, the laterality of a given individual is probably largely governed by hereditary factors but it is abundantly clear that this is not a simple Mendelian pattern. The geneticists have demonstrated for us that when interbreeding occurs over a considerable period between stocks carrying antagonistic traits, a certain amount of mingling of such traits may occur. The inheritance of laterality is far too complex to be analyzed from our present information. However, our current belief is that our cases of disordered cerebral dominance may be tentatively considered to be "intergrades" between left and right dominant patterns. Clinical findings of mixtures of handedness, eyedness and footedness, as well as many carefully garnered family histories have yielded much supportive evidence of this view.

Since the principle of unilateral brain control operates not only in reading and writing but also in the understanding of speech and in speaking and in learning to carry out skillfully many motor acts, our attention has also been directed to certain delays and defects in spoken language and to the abnormal clumsiness of some children, and interesting and instructive observations have been forthcoming here also. This extension of a promising field of study has been only surveyed and an opportunity for much profitable investigation undoubtedly exists here.

One striking yield of the successful remedial program in children who have suffered from any of these special disabilities is the improvement in the personality of the child. This often affects the child's interest, his self-confidence, his attention, and his willingness to work and frequently offers a corrective to misbehavior which arises as a reaction to his academic failures. Thus these studies offer marked promise in the fields of child psychiatry and education as well as in that of brain physiology.

UNIVERSITY OF PENNSYLVANIA

PHILADELPHIA

Samuel Torrey Orton

Citation for Honorary Degree of Doctor of Science

JUNE 18, 1945

Son of Ohio State University, of the School of Medicine of the University of Pennsylvania, and of Harvard University, you have directed research in neuropathology in the Pennsylvania Hospital; you organized the State system of teaching and practice of neuropsychiatry in Iowa, and more recently have served as professor of neurology and neuropathology in the College of Physicians and Surgeons of Columbia University.

Your cultivated insights into the relationships of brain structure and mental function have enabled you to recognize the causes of certain obscure mental defects of children and to put into practice corrective courses of training which have saved the intellectual lives of hundreds of our citizens.

APPENDIX

SAMUEL TORREY ORTON, M.D.

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